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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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OLDHAM-ROAD GOODS STATION, MANCHESTER; LANCASHIRE AND YORKSHIRE RAILWAY.

ONE great advantage of the war has been the emphasizing of the need for economy in man-power. In many respects the benefits accruing from the measures taken to minimise manual labour will have permanent effect. It can scarcely be said that labour has been cheap in this country, because the rates of wages for time or piece work have been greater than in most of the other European nations; they have, on the other hand, been such that there was, as compared with America, less inducement to invest capital for a problematic and probably evanescent advantage in increasing the output without a corresponding increase in wage cost. The call to arms of so many workers in all grades of industry, and the necessity, notwithstanding this, of carrying on business, not alone to provide the regular supplies for the army, but to maintain exports to pay for the war, has led engineers to consider closely the possibility of reducing the labour at present expended for a great variety of purposes.

We have in other articles directed attention to the measure of success achieved in some of the mechanical engineering establishments, and we are able now, with the assistance of Mr. John A. F. Aspinall, the general manager of the Lancashire and Yorkshire Railway, to illustrate means whereby the man-power on our railways may be more efficiently utilised. The need for such economy of labour scarcely requires to be emphasised. The railways, offering, as they do, the only method of inland transport of troops and material, are of vital importance, and yet events have proved that most of our railway workers are invaluable as units behind the fighting line. Any measure, therefore, to ensure economy of labour has a twofold advantage. Moreover, the example which we illustrate to-day is permanent, and the details published will, we hope, stimulate others carefully to consider the problem which has been so successfully tackled by Mr. Aspinall. The works comprised in the station were designed by Mr. D. C. Rattray, the company's chief civil engineer, and the mechanical and electrical appliances by Mr. G. Hughes, the company's chief mechanical engineer.

The present Oldham-road goods station in Manchester was originally the terminus of the Manchester and Leeds Railway, the passenger station being on a high level, while accommodation was afforded for goods on the low level, which was reached by hoists adjacent to the passenger station. When, however, in 1844, the main line from Miles Platting was extended further to a new terminal station (Victoria Station) in the business part of Manchester, the Oldham-road passenger station was altered so as to make it available for goods traffic. The goods yard was subsequently considerably enlarged by the inclusion of the area between the viaduct and Oldham-road, and a shipping shed and goods warehouse erected in the yard on the north side of the viaduct. An incline from the high-level line to the low-level yard was also constructed. Fig. 1 on Plate XIV gives a plan of the station as used for many years and as existing just prior to the recent extension, while Fig. 2 on the same plate is a plan showing the changes which have recently been effected. As will be seen from Fig 1, the high-level passenger station was, and continues to be, utilised as a grain warehouse, the wagons being manipulated within the building by electrically driven capstans, while hoists were used, along with the decline, for the transfer of wagons to the ground-level, where the warehouses, stores and transhipment shed were arranged. It will be seen that all the branch lines on the ground-level had dead ends, and that distribution was effected not by points and crossings, but by turntables. Of these there were formerly 93, which involved an enormous number of horses and men and a great waste of time in manipulating the wagons. Indeed, 60 per cent. of the traffic connected with the storing and transhipment of goods had to be done by the men, horses and capstans. Now practically every turntable has been dispensed with, while an enormous addition has been made to the facilities provided for the transhipment of goods, as well as for the distribution of consignments to the Manchester area, so that an enormously greater volume of traffic is handled every night with a greatly reduced staff and consequent considerable diminution in cost.

A comparison of the two plans will show that this rearrangement of the distributing line within the station and the supersession of turntables by points and crossings was effected by the inclusion of a large area of workers' dwelling-houses to the west of the station, a large block of modern workmen's dwellings being built by the railway company to house the people displaced by the extensions. The new area thus embraced within the station is approximately 282 yards long, with an average width of 88 yards. The thoroughfare on the western boundary—Thompson-street—has been about doubled in width—which is a great public convenience. On this additional area there has been built an entirely new shipping and delivery shed, with a fruit shed, and accommodation for carts and lorries, thus enabling the two old fruit warehouses to be removed, and the old shipping shed to be altered and converted into a storage shed, leaving the area so cleared to be utilised for the points and crossings in connection with the lines for the passage of wagons into the docks between the stages in the shipping and delivery shed.

The salient feature of the redistribution system is the arrangement of a great loop in extension of the decline, which connects with the various lines in the new shipping and delivery shed, and afterwards passes through one of the archways under the old overhead station and connects by other points and crossings with the extensive sheds for the storage and sale of potatoes for the Manchester market.

In the Oldham-road station yard there has been great gain by this rearrangement, and there are now in operation three gantry cranes for dealing with heavy items. One of these cranes is so disposed that one leg travels on the high-level railway and the other on the ground-level. This crane was originally operated by hand, and was used for articles of such bulk or length that they could not conveniently be conveyed around the radius of the curves on the decline to the ground-level. Thus heavy blocks of timber, for instance, were lifted from the high level, near to what is known as "The Mound," to the low level. The crane used for this purpose has now been reconstructed and is operated by electric power, the lifting capacity being 5 tons. Another of the gantry cranes is situated close to the goods warehouse, which, by the way, is now used for grain instead of the extensive dye materials formerly imported from Germany, but now manufactured in this country. This gantry, which travels on timber columns, has a lifting capacity of 10 tons. A new Goliath travelling crane has been arranged on a track parallel with the old high-level viaduct, and this forms the subject of one of the illustrations on Plate XVI (Fig. 14). This crane is of 20 tons capacity and has been designed with a special view to speed of working. It has a span of 45 ft. 4 in., covering two wagon roads and a 24-ft. wide cartway, with a clear height of 25 ft. to the underside of girders. Separate motors are arranged for longitudinal travel, cross travel, main lifting, and auxiliary lifting, the latter being provided for dealing at a high speed with light loads up to 30 cwt. on a single fall of rope. The working speeds with full loads are:—Longitudinal travel, 300 ft. per minute; cross travel, 150 ft. per minute; main lifting, 20 tons at 15 ft. per minute; main lifting, 10 tons at 30 ft. per minute; auxiliary lifting, 30 cwt. at 150 ft. per minute.

The most important improvement in the station as rearranged is undoubtedly the construction of the shipping and delivery shed and fruit shed on the added area to the west of the old station, and drawings of this building are given in Figs. 3 to 9, Plate XIV, and in Fig. 10, page 170. These illustrations show clearly the constructional details of the building and its general arrangement. The southern and main part of the building, as shown on the plan, Fig. 2, consists of eight bays, seven of which have each a span of 42 ft. 6 in. and the other a span of 44 ft. 6 in., and in one of the bays there is provided a cartway 31 ft. wide, forming part of the accommodation for the distribution of goods in the city of Manchester. The construction of these bays is very simple and yet appropriate. The principals, which are placed 13 ft. 1 in. apart, are of steel of the "Belgian" truss type, consisting of a T back with struts and ties of flat bars. These principals are carried by steel open web girders, supported by steel stanchions placed 39 ft. 3 in. apart, built up of plates and angles. Attached to each column are steel brackets supporting solid-web girders carrying the travelling cranes. The purlins are of timber, and the roof is partly boarded and slated and partly glazed, about one-half of the area of the roof being glazed. There is a continuous ventilator over each bay, fixed at the the apices of the principals.

To the north of this transhipment shed there is the new fruit warehouse. The design of the building was influenced by the fact that the area, as shown in the plan, was of irregular dimensions. Two bays are parallel with those of the transhipment shed, the span of one is 50 ft. 6 in. and of the other 51 ft., the latter being over the dock railway track which enters the fruit shed, and equipped with a 2-ton overhead travelling crane. The construction of these two spans, so far as regards the roofing and columns, is practically the same as those in the transhipment shed, except that the steel members of the principals are slightly heavier, due to the increased span. The remainder of the building northward is built in spans at right angles to those already described, with the ends of each bay hipped, as shown in section A–A (Fig. 9) and in various elevations (Figs. 3, 4 and 8). The principals, stanchions and girders are of a type similar to those in the transhipment shed.

The chief interest, however, is not so much the constructional detail as the admirable arrangement of the interior, particularly of the transhipment shed. In all railways there is involved an enormous amount of transhipment work every night. Some idea of this is indicated by the fact that accommodation is provided in this one shed for 112 wagons, for dealing with inter-station traffic in Yorkshire alone, and that on an average 60 to 70 wagons come in every night, and are unloaded and reloaded, the parcels and other consignments of goods being transferred from one wagon to another. The plan on page 170, Fig. 10, gives some idea of the general arrangement, while the photograph reproduced on Plate XV (Fig. 11) gives a view of one of the bays. The stages between the track are divided up into areas, each allocated to a definite station on the line. The names of these are printed in bold letters, as can be seen from the view in Fig. 11. They are grouped geographically, for facility in distributing goods. The work of the traffic superintendent is to have parcels unloaded from all wagons and each transferred to the area on the stage allocated to the station of destination. To facilitate this, overhead electric travelling cranes, with a capacity of 30 cwt., are provided in the bay. These cranes are eight in number, seven of them having a span of 39 ft. 2 in. and one of 41 ft. 10 in. They are of the usual modern overhead electric three-motor type, having separate motors for longitudinal travel, cross travel, and lifting. The working speeds are:—Longitudinal travelling, 480 ft. per minute; cross travelling, 150 ft. per minute; lifting, 150 ft. per minute.

If the station of destination of the goods is not in the same bay, the crane deposits the goods on electric trucks on a platform at right angles to the docks and communicating with all the bays and stages in the transhipment shed. These trucks are both electrically driven and controlled and are of the storage-battery type, designed for transporting goods, and can be used where space is limited; the platform of the truck is low, which assists considerably in the handling of heavy articles or packages. The driver stands on a small platform at the front of the vehicle, operating the steering lever with his right hand, and the motor controller with his left hand. This platform is divided into halves: the left half, when depressed by the driver standing on it, acts as a switch, and allows the truck to be operative; the depression of the right half of the platform releases the brake, which is then applied by the driver raising his right foot. All four wheels are controlled

simultaneously, the direction in which the truck is turning being indicated by the position of the steering handle. The trucks are driven through double-reduction spur gearing on to the front driving wheels.

Trailers have been adopted for use in connection with the warehouse trucks. They are mounted on cast-steel wheels fitted with solid indiarubber tyres. They can be readily coupled up to the electric trucks at either end, and the axles being of the swivel type and coupled together, the trailers can be operated in a limited space, as is the case with the electric truck. Flat bottoms are also employed, fitted with four lifting brackets for lowering on to the trucks or trailers to save time in loading or unloading.

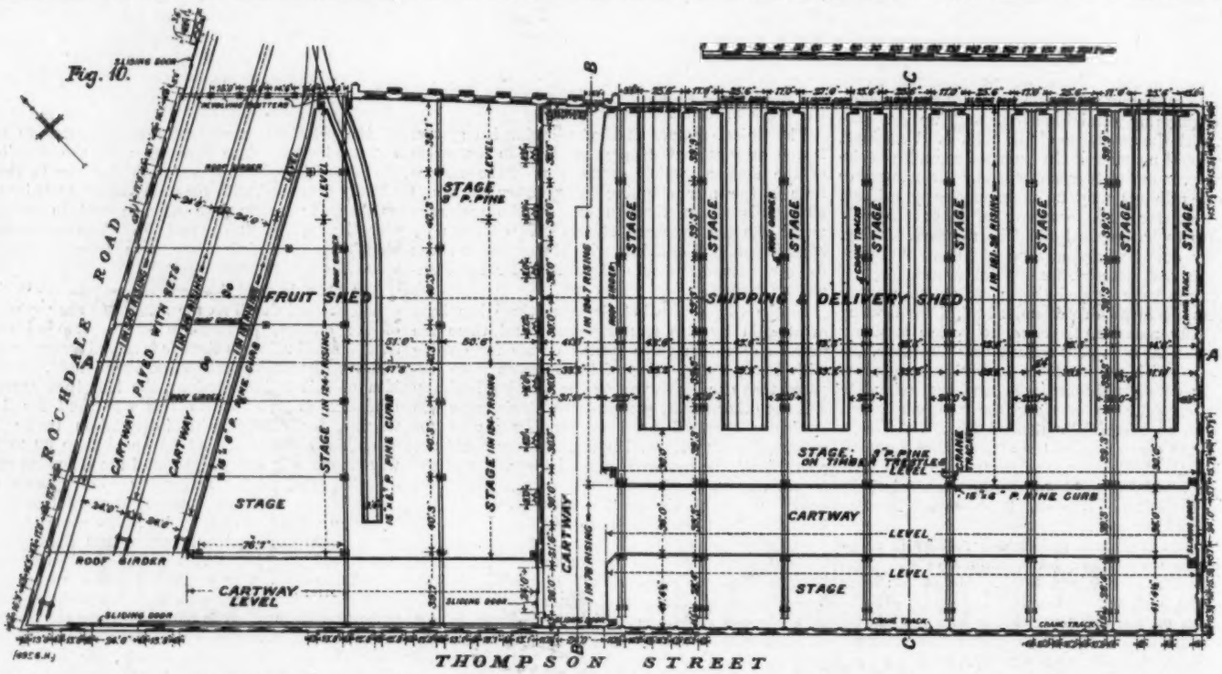
The goods are conveyed by such trucks to the bay in which is located the station of destination, and the overhead crane in such bay lifts the goods from the truck and deposits them on the stage at a point allocated to the destination. It will thus be seen that no goods are deposited on the stage except directly in the area provided for the station of destination.

In certain cases there are goods which for some reason cannot be thus placed in the area provided for their station of destination. In such case the goods are conveyed by the overhead traveller to a separate stage, arranged for their temporary storage. This stage occupies the whole length of the western end of the shed and is divided from the transhipment stages by a cartway for the distribution of goods within Manchester.

A feature of this storage stage is the mono-rail jib crane of 30 cwt. capacity, which travels on a rail supported on brick piers along the inner wall parallel with Thompson-street. This crane is shown in the engraving, Fig. 12, on Plate XV. An interesting feature shown by the photograph is the arrangement of the ends of the girders carrying the travelling cranes in each of the bays, so that they do not interfere with the traverse of the electric mono-rail crane. This crane, which has a radius of 15 ft., has three motors, viz., one for lifting, one for travelling, and one for slueing. The whole weight of the machine is taken through the two travelling wheels on to an ordinary flat-bottom rail, the upper end of the crane being kept in position by a vertical roller fixed on a centre pillar and running inside a channel section bracketed to the shed wall. The view, Fig. 12, is self-explanatory. The speeds of working are as follow:—Hoisting, 100 ft. per minute; slueing, 200 ft. per minute; travelling, 425 ft. per minute. The idea of having a traverser is that goods transferred by the overhead travelling crane from the wagons in each dock and deposited on the storage stage may be traversed to another bay, so that they can be picked up by the overhead traveller and put in place in the area allotted to the station of destination or in wagons in the dock.

It will be seen from the plan, Fig. 10, that a cartway paved with setts and 36 ft. wide is arranged between the ends of the transhipment stages and the storage stage, and one 31 ft. wide along the northernmost bay. A perspective view of these cartways is shown in Fig. 13, on Plate XVI, which affords a very good idea of the eight bays constituting the transhipment shed, with the overhead cranes traversing the bays. It may be noted that the storage stage is located to the left, although not seen in the view. Here, again, care has been exercised in facilitating the distribution of the goods to the lorries. Manchester is divided into a number of definite areas, and each of these has a number.

Fig. 10.



The lorry for each district has a definite stance in the cartway, and standards are arranged showing the number and the streets in each district. This standard can be placed in a hole on the loading stage, so that those engaged in traversing the goods from the wagons along the stages, in hand or electrically propelled trucks, know exactly the location of the lorry on which the goods are to be loaded. Horse lorries, it may be said, are almost exclusively used, because experience has shown that the distances traversed do not economically justify the use of motor lorries. As is shown on the general plan of the station, Fig. 2, stabling is found in the archways under the high-level station, and as an indication of the completeness of the scheme, it may be said that there is a tarpaulin repairing shed close beside the exit, with roller apparatus for exposing the tarpaulins to the light to ascertain if there is damage and where it is situated. At the same time repairing appliances are provided for repairing such damage. It is worthy of note also that the Oldham-road station is in close proximity to the Manchester markets.

The fruit shed is located to the north of the shipping and delivery shed. As a rule the loads here are light, and the principal requirement is for sufficient area for dealing with the packages. There is a dock with one line of rails, and this is equipped with an overhead crane, running the full length of the shed and having a capacity of 2 tons. In construction it corresponds generally with those used in the shipping shed. Here there is a cartway on two sides of the extensive floor area of the stage, so that the fruit packages can easily be loaded and carted off to the market. An interesting feature in all crane operations within the station is that large wooden carriers are provided for collections of parcels, instead of slings, as is shown in Fig. 14, Plate XVI. For the potato traffic there are two large sheds adjacent to the old passenger station. The potato traffic at this station has always been very extensive, and the new arrangement of lines, dispensing with turntables, will be a great convenience.

A word in conclusion should be said about the offices at this station, as they indicate that the company have a great desire to promote the comfort of their staff. These offices have a frontage to Oldham-road and are three stories in height, with a flat roof. They are admirably lighted, are heated and ventilated on the plenum system, and have electric light and electric hoists. There are separate dining-rooms for the men and women workers, run by a committee of the staff, and arrangements are made for entertainments organised by the workers. Access to the roof is provided, and it forms a promenade at meal hours and on other occasions.

Thus it will be seen that from first to last the rearrangement of the Oldham-road goods station affords an admirable lesson, pointing the road along which economy in man-power can be achieved. It is true that some of the details are already applied in other stations, but it will be accepted that there is room in many stations for the adoption on many of our railway systems of the same or corresponding details in order to ensure rapidity and economy in the transhipment of goods.

THE FLOW OF WATER IN WOOD-STAVE PIPE.

The increasing demand for water for irrigation purposes, town supply, the development of power and other uses has necessitated its conveyance by means and in volume not contemplated a few years back. To satisfy this demand it has been necessary to construct pipes of large diameter, and at a cost that should not prove prohibitive. When the aqueduct from the Catskill Mountains to New York City was constructed, over some part of the road pipes 11 ft. in diameter were employed. These were constructed of steel, lined with 2 in. of cement mortar, and embedded in concrete. That, no doubt, was an effective but an elaborate and costly proceeding that could not be imitated for similar projects in less wealthy communities. A more economical method had to be found, and the wood-

stave pipe has supplied the want. The general appearance in alignment and profile is shown in Fig. 1. Such pipes are now successfully built up to 13 ft. in diameter, precautions being taken to prevent collapse by providing additional support to the lower parts. These huge structures having been reported upon as well adapted for conveying large volumes of water under low or medium heads, their employment in many industries is assured, and it becomes a problem of increasing importance to determine with accuracy their carrying capacity and to investigate the causes that hinder or promote their efficiency. The examination of the question, involving work that is trying in the field and onerous in the computing room, has hitherto been only partial in its character. It was needful that the whole mass of existing data should be brought to bear, and it is fortunate that this task has been undertaken by Mr. F. C. Scobey, whose previous investigation into the flow of water in irrigation channels has given him great experience and taught him the sources of error and the difficulties that have to be overcome. He has now published* the

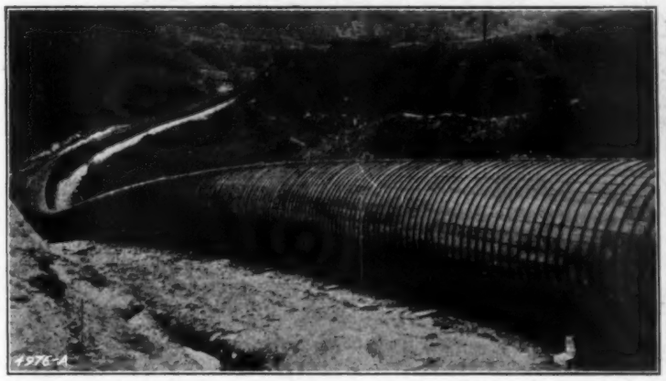


FIG. 1. GENERAL APPEARANCE OF WOOD-STAVE PIPE.

FIG. 2. METHOD OF ATTACHING MEASURING APPARATUS TO THE PIPE.

results of his inquiry, and in so doing has increased the value of his work by adding the criticisms of several competent authorities, to whom he submitted his results in MS. These criticisms are only second in importance to the original memoir, and we hasten to add that these authorities, most of whom have been engaged in similar inquiries, acknowledge the care and ability shown in the collection of the observations, and the thoroughness with which the details have been discussed.

The grounds for undertaking such an inquiry lie in the need for substituting a more reliable rule than that supplied by the Kutter formula, and one more applicable to the problem in question. This well-known formula, which can be written in the form

$$V = \frac{\frac{C}{n} + C^1}{1 + \frac{C^1 n}{\sqrt{R}}} \sqrt{R s}$$

where C and C^1 are constants, R and s have the usual significance, and n, a factor which includes all the retarding influences, has been presumed applicable to wood-stave pipe. This expression has met with more confidence than it deserves; it was not devised by the original authority to meet the case of water flowing through pipes, running free, and under pressure. The varying values assigned to this coefficient of retardation, n, by investigators testify to the degree of dissatisfaction experienced in the use of the formula. In the particular case of stave-wood pipe n has been assigned a value differing but little from 0.1, and occurring as it does in the denominator c/n, any error in this assigned value would have a considerable effect on the numerical value. Considered as a criterion for estimating the capacity of wooden pipes, it is doubtful whether n has any real physical meaning. It is introduced as a factor to secure harmony in the observations, by embracing all and every source of irregularity. An attempt has been made to show that n increases with the radius R, and up to 36 in. this suggestion meets with some support, but the newer larger-diameter pipes of 144 in. and 162 in. give values comparable with quite moderate pipes. In the uncertainty that prevails the author will have the approval of water engineers generally in insisting upon the fallacy underlying the use of a constant value of n, and of all those who have desired a more scientific and more trustworthy means of calculation.

In forsaking the beaten path Mr. Scobey proposes a formula of exponential type. In the expression for the hydraulic gradient we have long been accustomed to the formula $i = K Q^m / D^n$, and therefore it seems a slight step in advance to write $H = K V^m / D^n$, where H is the loss of head by friction and V the mean velocity. The author does not justify the form of the function, but simply asks for a formula that will fit observed facts, and he was no doubt influenced by previous writers, whose values he has collected with some completeness.

Mr. Gardner Williams proposed	$H = 0.38\ V^{1.8}/D^{1.25}$
Mr. Moritz	$H = 0.38\ V^{1.8}/D^{1.26}$
Messrs. Williams and Hazen ...	$H = 0.469\ V^{1.852}/D^{1.167}$
The author's final formula is...	$H = 0.419\ V^{1.8}/D^{1.17}$

These formulæ differ apparently but little, and to those who are unaccustomed to work with powers, the agreements may appear closer than they are. Some of the numbers look so nearly identical that the necessity for further inquiry is not apparent. For example, the exponent of V in the author's formula is precisely the same as in that due to Mr. Moritz, and the diameter is raised to nearly the same power. This similarity makes a comparison of the results of the application of the two formulæ to a pipe of given diameter a very simple matter. Taking 6 ft. as an average diameter, the difference of discharge in the two cases amounted, roughly, to 16 per cent. It is not creditable that the calculated discharge should be accompanied by such uncertainty, but these figures are useful to show that Mr. Scobey has been engaged in an eminently practical service by endeavouring to derive a formula that should be applicable to all stave-wood pipes of circular section. To be in possession of a theoretical value that would receive the sanction of a Government department, and one on which tables and diagrams might be based authoritatively, would go far to dispense with those factors of safety that are occasionally necessary when penal clauses are inserted in contracts. This is an obvious advantage, but whether it is possible to assign numerical constants and powers to an expression that will give the loss of head in all stave-wood pipes, of whatever age and condition, in which the diameter may vary from irregularities of pressure or from the quantity of silt, vegetable growth, and other causes, is open to question. What Mr. Scobey has done is to make a very careful examination of the circumstances which affect the conveyance of water in many pipes of this class, and to collect an amount of information from which may be concluded the margin of error or divergence to be expected in any particular case.

The data required for the solution of the problem are not many, and the instrumental equipment is fairly simple. The object is to ascertain the mean velocity of the water in the pipe and the loss of head due to friction in a section of known length and diameter. The former can be determined either by timing the passage of a given volume of water through the known distance, or measuring the discharge of the pipe when the velocity is derived from the equation, $V = Q/\frac{1}{4}\pi D^2$. Both these methods were employed by Mr. Scobey, and it is believed that the operation of timing the passage of water in the pipe leads to the more accurate results. The loss of head is shown by the reading of piezometer tubes inserted into the wooden tube. The theory of these is very simple and the interpretation of the results trustworthy within a small margin. If, at different distances from the reservoir, small tubes be inserted vertically in the pipe, the level of the water in the tubes will rise to that of the reservoir if the water is at rest. When the water in the pipe is in motion, these levels sink on account of loss of pressure due to frictional resistance in the pipe, the level in the tubes more remote from the reservoir falling more than in those nearer to the inlet. Consequently the difference of the levels in the piezometer tubes is a measure of the frictional resistance in the length of pipe separating the tubes. This difference may measure or include other unknowns which it is the business of the experimenter to eliminate. These troublesome sources of error would receive every attention from an observer so skilled as Mr. Scobey, and in his capable hands we are content to leave such questions as the choice of position for fixing the gauges to the pipe, the method of attachment, and the exclusion of all extraneous influence on the tube readings.

Fig. 2 shows the method of attaching the mercury manometer, a necessary adjunct where the difference of pressure is so great that glass tubes of an inconvenient length would be required, and Fig. 3, page 172, shows the assembled parts. The method of working can be easily followed, but the tube X Y Z may need a word of explanation. This part of the apparatus is used in connection with the direct measurement of the mean velocity by the method of injecting into the water a highly coloured material (fluorescein) and observing the time of its discharge. "The coupling W is opened and the solution (of fluorescein) poured into the pressure tube X. The gun is again connected with the apparatus by the coupling W. With E closed, V is opened. Pressure in the wood pipe enters the gun, making pressures in both gun and pipe equal. In order to inject the colour into the pipe the only thing necessary is to increase the now existing pressure in the gun. After V has been closed the gun is pumped up like a bicycle tyre. While noting the time the operator opens the cock V. This arrangement ensures the uniform distribution of the colouring matter throughout the section at the point of application." The time of arrival at the outlet will vary. The discharge

* "The Flow of Water in Wood-Stave Pipe." By Fred. C. Scobey, Irrigation Engineer; with discussion by Gardner S. Williams, J. A. Noble, D. C. Henny, E. A. Moritz, E. W. Schoder, and L. M. Hoskins. Washington: Government Printing Office, 1916.

of the water takes place under a different head at different parts of the tube outflow, and when the diameter is large this effect is by no means negligible. The author states that the effect of the colouring material is noticeable about 8 per cent. of the total time the colour spends in the pipe, and it is believed that the colour method is trustworthy within about 3 per cent. The method of current meters is less accurate. Mr. Gardner Williams states in the accompanying discussion that the use of a current meter in a tail race is very unsatisfactory, and its indications are liable to be in error anywhere from 10 to 20 per cent. We desire to associate ourselves with this expert opinion. Where the condition of the water is turbulent or unfavourable from any cause, large errors are introduced.

A source of error that remains, and one for which no effective remedy can be suggested, arises from the impossibility of determining the interior diameter of the pipe with accuracy. The author guarded himself as far as possible by measuring unused portions of the pipe, templates used in the construction, and the external circumference, making allowance for the thickness of material. He could do no better; but it seems inevitable that the pipe should lose its strictly circular shape, and become more or less elliptical or irregular in form. In addition, there can be no doubt that in some cases silt would accumulate and growth attach itself to the inside of the pipe, reducing its available diameter and introducing appreciable sources of error that would affect the exponent of D. In such a term small alterations of the diameter, say, of 1 per cent., would cause an error of the same order of magnitude in the exponent. Yet errors amounting to one-hundredth cannot be excluded. Mr. Noble calls attention to the fact that saturation, which would lead to swelling of the wood, that distortion from various causes, and inaccuracy of manufacture would form sensible sources of error. Of this last uncertainty, he instances a 54-in. pipe, where from actual measurement he found the internal diameter ½ in. larger than the normal, making a difference of 1.8 per cent. increase in the area.

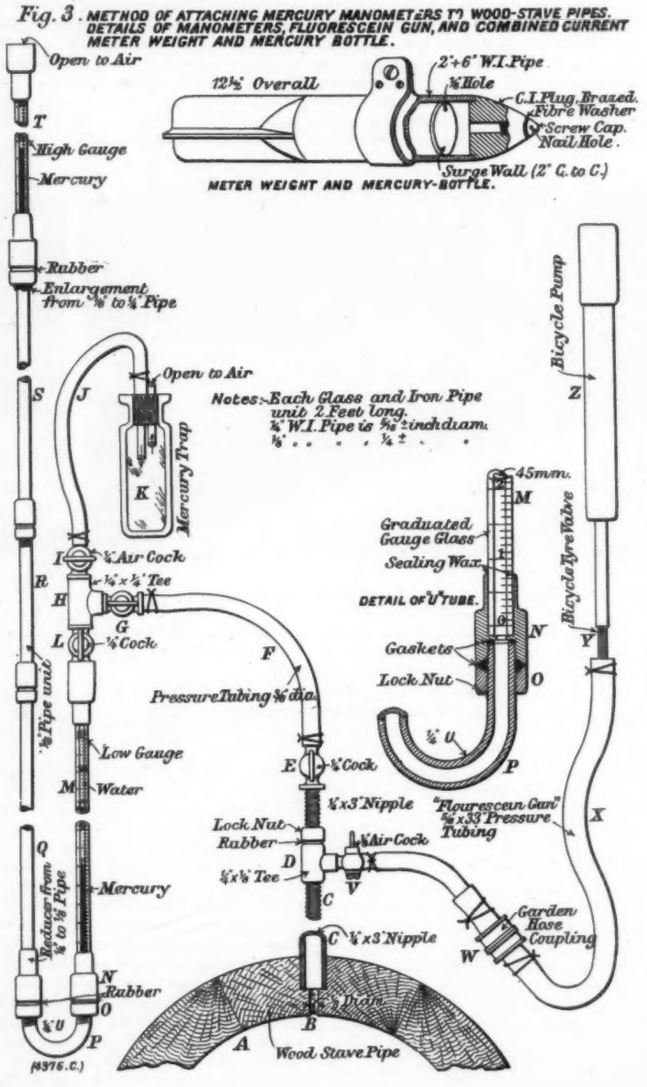
Underlying this question of providing a formula that shall express the discharge in terms of the velocity and the diameter, there is the further problem of determining the degree of accuracy that can be expected in hydraulic measurement. To such an inquiry Mr. Scobey makes a very valuable contribution, apart from the main purpose of this investigation. His heroic attempt to harmonize all previous measures and represent them by a single formula may well be defeated by the inevitable errors—accidental and systematic—that unconsciously accompany the efforts of previous observers, but the additional information he provides throws light on the nature and extent of these irregularities. We could have wished that more indications had been given of the estimated errors in the measurements. It is only after comparison and discussion have revealed essential disagreement that the need of additional precautions and greater precision is forced upon the experimenter in order to demonstrate that the legitimacy of his conclusions is not affected by the presence of extraneous circumstances leading to a misinterpretation of his observations. The tendency of experiment must always be towards greater exactness. Mr. Scobey, being last in the field, profits by his predecessors' experience. For these and similar obvious reasons we would have preferred that he had discussed his own observations separately. They are sufficiently numerous and varied to warrant such independent treatment. They include measurements made on 36 pipes of various dimensions, ages and conditions. In size, the greater number range from 8 in. to 4 ft. in diameter. One was 6½ ft., and the list concludes with two mammoth pipes with diameters of 12 ft. and 13½ ft. respectively. The circumstances under which the observations were made would prevent the results being strictly comparable, but at least the influence of the personal element would be reduced. The plan adopted tends to force an agreement between many incongruities, and finality seems hardly possible. As one of the critics points out, another person working with the same data as a basis would arrive at a different conclusion than that here presented, and the possibility of yet another formula is not excluded. If this means, as we think it does, that the problem does not admit of a unique solution, we must agree with the remark. The subject of weighting is especially difficult and uncertain, and it may be doubted whether the plan adopted by the author will be generally approved. It receives little support from the usual practice founded on the discussion of the theory of errors.

In order to obtain the numerical coefficients in the exponential equation that shall represent the whole of the collected observations, Mr. Scobey has adopted a graphical process that is not very easy to follow. The diagram attached does little to remove the obscurity. Presumably there are reasons for this course which are not apparent on the surface. It may be that by this process the more discordant measures are made prominent, so more easily weeded out, and in some cases a weight of zero has been assigned. Possibly to those familiar with this form of analysis the diagram tells more than it does to the inexperienced. But having selected an equation of the form

$$\text{Log } H = \log K + x \log D + z \log V,$$

in which the coefficients of x and z are known very approximately, it seems possible and advantageous to introduce small corrections to these unknowns and construct a series of equations of condition that can be regarded as linear. There may be practical difficulties in the way of such procedure, but certainly if such a method could be adopted the theoretical probable error attached to the value of the unknowns could be determined, and would provide a better measure of the trustworthiness of the result than the criterion furnished by the author, to the validity of which we cannot subscribe. Mr. Scobey has computed from the known loss of head and diameter of the pipe the velocity from the formulæ given by various authorities, and compared the computed with the observed values of velocity, expressing the differences in percentages. Some of these differences are very large, frequently exceeding 20 per cent., implying not necessarily that the observations are defective or inaccurate, but that they do not all refer to the same aspect of the general phenomenon. The formula that makes the mean of these residuals a minimum is considered the most fitting solution, a rule that will naturally give the place of honour to the last-comer, who has the greatest number of facts before him. Mr. Scobey, however, contends that his expression should be accepted "because the mean of all the observations entering into the derivation of the general value of the exponent agrees with the formula to within 0.33 per cent." In a similar table in which all the measurements of each pipe are grouped, the formula again agrees with the mean to within 0.66 per cent. These small differences do not convey a great deal. They merely indicate that the curve passes through the mass of individual observations without indicating the amount of deviations either side of the

Fig. 3. METHOD OF ATTACHING MERCURY MANOMETERS TO WOOD-STAVE PIPES. DETAILS OF MANOMETERS, FLUORESCEIN GUN, AND COMBINED CURRENT METER WEIGHT AND MERCURY BOTTLE.



mean. Parenthetically, it may be noticed that the deviation of the Williams–Hazen formula from the general mean (page 37) is + 2.41 and not 24.1 as printed. The difference between 2.4 and 0.3 from the general mean is not vital, as a study of the graphical representation of the deviations will show. Of this diagram, Mr. Henny writes: "It shows the lack of consistency which appears, in the nature of the case, to attach to the results of various experiments." This view is confirmed if we derive the probable error of a single observation, treating each residual as an error. As it would be a long task to square all the errors, the abbreviated form of the mean of the errors, neglecting the change of sign, has been used. The results are as follow:—

	Per cent.
Scobey	8.0
Williams-Hazen...	7.5
Moritz	10.3
Tatton	8.1
Welsbach	9.3

Since there is no great difference among these quantities, it might fairly be urged that any one formula is as good as the others, and that was Dr. Schoder's opinion, who writes that he "considers the author's formula as good and as safe as any." Another inference that may be drawn is, that had a least square solution been pursued, the probable errors attaching to the corrections would be far greater than the corrections themselves. Such a result would give support to another critic, Mr. Moritz, who remarks that "the present paper cannot be considered as the final answer to the problem of flow of water."

It is to be hoped that none of the remarks here made will convey the impression that Mr. Scobey's paper is undervalued. The close examination bestowed upon it should be proof of its intrinsic worth. But it may not be unnecessary to guard against the belief that the formula, and the tables, diagrams, &c., founded upon it, possess a quite unattainable degree of accuracy. The author is under no misapprehension on this head. He advises a considerable margin of safety, knowing only too well how disturbing influences enter and vitiate results. He quotes elaborate measurements on selected pipes, in which the conditions for experiment were made as perfect as possible, that exhibit errors amounting to 7 per cent. Considering the field difficulties that have to be overcome in testing pipes in actual use for commercial purposes, it is remarkable that the mean errors are not greater than here quoted. Mr. Scobey has been engaged in a great and important work, and we should like to endorse Professor Hoskin's comment, "This experimental work is a valuable addition to knowledge on the subject, and the author's summary of conclusions appears to merit confidence as embodying present knowledge on the hydraulics of wood-stave pipe." We believe that the task of a final solution is impossible at the present stage, notwithstanding the devoted zeal and ingenuity the author has brought to bear. He has thrown light on doubtful points and placed the theory in a more satisfactory position. He has demonstrated that in Kutter's formula no constant value can be assigned to n that will be applicable to the flow of water in wood pipes varying in calibre and velocity of flow. This may be a negative result, but it is one of great value, and its effect will be felt in the increasing accuracy of all future measurements of capacity. The examination of the effect of age upon the efficient capacity of pipes is of high practical importance. This form of construction is of recent introduction; it is still on its trial. To know that a pipe 24 years old is operating satisfactorily is very welcome and reassuring information, supported as it is by the fact that pipes up to seven years of age show little sign of deteriorating. The comparison of capacity between wood and iron on steel pipes raises points that will engage the attention of the engineer, while the loss of head due to the method of connection with the reservoir is of theoretical interest for the student of hydraulics. Similarly the discussion of the influence of air carried in the water at low and high discharges and the remedies for this inconvenience is instructive. To dwell on these matters at any length would divert attention from the main subject of investigation, but they contribute materially to its completeness.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics, in the course of an article on the Labour Market in January, which is published in the *Board of Trade Labour Gazette*, states that the detailed monthly reports for January received from employers' associations, individual employers, trade unions, the trade and local correspondents of the Department, and the Employment Exchanges, all reveal the great demand for labour and the insufficiency of the present supply. It is therefore necessary that the volume of labour should be increased by tapping new sources of supply, that skilled workers should be "diluted" as far as practicable, that all work which is not absolutely essential during the war should be restricted, and that, after meeting the requirements of the Army, the manpower of the country should be concentrated on work of national importance.

The change in rates of wages reported as taking effect in January affected over 660,000 workpeople, and resulted in a net increase of 42,600*l.* per week. The principal increases reported affected workpeople in the cotton weaving; woollen and worsted; printing, dyeing, finishing, &c.; linen; and hosiery industries (accounting altogether for over 520,000 workpeople). The only decreases reported affected coal miners in Northumberland, and some steel-workers employed by one firm, both decreases being due to the operation of sliding scales under which wages are directly regulated by prices.

The number of disputes beginning in January was 19, and the total number of workpeople involved in all disputes in progress was 6,774, as compared with 36,627 in the previous month and 11,697 in January, 1916. The estimated total aggregate duration of all disputes during the month was 24,500, as compared with 157,300 in December, 1916, and 97,600 in January, 1916.

The average weekly number of vacancies notified to all Employment Exchanges for the five weeks ended January 12 was 35,296, as compared with 39,572 in the five weeks ended January 14, 1916. The average weekly number of vacancies filled for the same periods was 25,714, 30,405 and 23,352 respectively.

Retail food prices in the United Kingdom on February 1 were between 1 and 2 per cent. higher than a month earlier. As compared with February 1, 1916, retail food prices showed an advance of about 30 per cent. Compared with July, 1914, the general increase on the 1st inst. was 89 per cent. By certain reductions, substitutions and omissions from the dietary the Board of Trade calculates that instead of 89, the increase becomes about 50 per cent. only. No comparison can be instituted between British and German and Austrian prices, since no official figures have been received from Berlin or Vienna.

In his monthly report for February, the general secretary of the United Society of Boiler Makers and Iron and Steel Shipbuilders states the following:—"Since the beginning of the war Germany has concentrated on a standardised type of submarine boat, and she has turned them out at the rate of about three per week. And now the grand attack on our vital artery has begun. It is not so serious as to make us afraid. But it is serious enough to stimulate all of us to pool our assets and our services in the national interest. Our trade has been recognised as one of the most important in the successful prosecution of the war. In view of the latest developments it is now of more importance than ever. The output and repair of ships of all kinds depends primarily on our members. I need not now appeal to you to let no personal interests come between you and the vital need of the nation for the most and best you can give. You have lent the nation over a quarter of a million pounds of your money through the society, in addition to your personal investments in the loan. You have given your service in a way which has received the frank appreciation of the Admiralty on many occasions. You have not failed in your loyalty up till now. You will not fail in this supreme and final phase of the struggle for justice and liberty to the common people of all nations."

Speaking at several meetings, both in London and in the provinces, during the last few days, Mr. John Hodge, M.P., Minister for Labour, stated he believed that after the war we were going to have a great period of booming trade. All the industries which had been turned into shell-making and munition-making must lay their plans now for the change and not wait until peace was declared . . . . Labour Exchanges should be established in main thoroughfares, and this was necessary since Labour Exchanges would take a large share in the demobilisation of the troops.

In the course of a tour throughout the Midlands and the Northern Counties Mr. Arthur Henderson spoke of the war and the industrial position. He felt confident that the Allies had got the measure of the enemies and would strike a blow which would lead to final victory. What was now needed, he added, was to secure a body of labour which could be made mobile and could be easily transferred with the least possible dislocation of industry. . . . Referring to the great part which organised labour had played in the war, Mr. Henderson said that no class of the community had displayed more splendid patriotism and a more unswerving loyalty to the interests of the community and to the Allied cause than had the trade union movement. Organised labour was going to stand true and loyal to the end, until all our united efforts had resulted in a final and complete victory for our cause. Never again should the working class go back to the position it was in immediately before the outbreak of hostilities. He hoped they had constituted, by what had occurred, a co-partnership between the State and the majority of the people; as years went on this co-partnership would grow closer and closer, stronger and stronger, and would develop to the mutual interest of the State and of the working population. If the State recognised that it depended on capital and labour, he hoped capital and labour would recognise that a sort of triple alliance had thus been formed, the members of which ought to work together for the good of all. . . . The supply of munitions was at this moment many times greater than it was when we began the battle of the Somme. Notwithstanding this fact, we had not yet all the supplies we wanted. While we had large stocks, we were not going to rest there; we were going to leave nothing to chance. If one ounce more could be put into the building of ships for the mercantile marine, it should be done. But we were going on at the same time with our naval programme.

The Committee on Production heard, on January 12, 1917, applications for an advance of wages made to the Shipbuilding Employers' Federation by the Boilermakers' and Iron and Steel Shipbuilders' Society and by the societies affiliated to the Shipbuilding Trades Agreement Standing Committee. The Committee deferred giving an award on the case, the applications being such as, in their opinion, should be considered in conjunction with proposals for general changes in wages in the shipbuilding and engineering trades which are about to be dealt with. The Committee now understand that another tribunal will hear the claims made in connection with these proposals. In these circumstances the Committee's decision on the present claims is that they should be considered by such tribunal as may be appointed to determine the general claims, when that tribunal will have before them all the circumstances of the case, together with the full report of the proceedings on these claims before the Committee on Production.

The above decision is signed by Sir G. R. Askwith, Sir D. Harrell, and Sir George S. Gibb.

PHOTOGRAPHIC COLOUR PRINTS ON SILK.—The Manufacture Nationale des Gobelins has recently adopted the process of Messrs. Vallette and Féret for photographic colour printing, the process being applied to articles de luxe that cannot well be printed by machine. Three successive impressions are made, in blue, yellow and red. The precision which is required in the superposition of the three impressions is secured by means of a special frame on which the article is stretched with the aid of metallic eyelets. The sensitisers used are alkaline phenols and diazo sulphites, and the colours are developed by exposure to the electric light.

COMPULSORY RETURNS OF ALUMINIUM.—The Minister of Munitions orders that all persons shall, in the first seven days of each month, commencing in the month of March, 1917, send to the Director of Materials, A.M.2.(H.), Hotel Victoria, Northumberland-avenue, London, S.W., monthly returns of:—(*a*) All aluminium held by them in stock or otherwise under their control on the last day of the preceding month. (*b*) All aluminium purchased or sold by them for future delivery and not yet delivered on such last day, together with the names of the sellers to or purchasers from them. (*c*) All aluminium delivered to them during the preceding month. (*d*) All aluminium scrap or swarf produced by them and/or issued from their works during the preceding month. (*e*) All contracts or orders existing on the last day of or entered into during the preceding month requiring for their execution the use of aluminium, specifying the purposes thereof. No return, however, is required from any person whose total stock of aluminium in hand and on order for future delivery to him has not at any time during the preceding month exceeded 56 lb. For the purpose of this Order the expression aluminium shall mean:—Aluminium and alloys of aluminium, unwrought and partly wrought, including ingots, notched bars, slabs, billets, bars, rods, tubes, wire, strand, cable, plates, sheets, circles, strip. Aluminium scrap and swarf, aluminium alloy scrap and swarf, remelted aluminium scrap and remelted aluminium alloy scrap and swarf. Granulated aluminium, aluminium powder, "bronze" "flake" and "flitter." Failure to comply involves liability to penalties of fine and imprisonment. All dealing or negotiations for dealing in aluminium without a permit is illegal and a punishable offence.

PRESERVATION OF TIMBER FROM BORING ORGANISMS.

The results obtained from Australian tests of the Carbo-Teredo process for the preservation of timber from marine and land borers, to which we referred in vol. cii, page 346, are illustrated by the photographs reproduced in Figs. 1 to 4 on the present page, these photographs being selected from a number supplied to us by the inventor, Mr. J. E. Cunningham, of Sydney.

Figs. 1 and 2 illustrate sections of ten timbers of Oregon pine which were laid under the Pyrmont Grain Wharf, Darling Harbour, Sydney, on July 20, 1914; they were lifted on March 19, 1915; re-submerged on April 30, 1915, and lifted for the second time on June 1 of last year. In this case all the untreated timbers were destroyed, whilst the treated ones were intact. Figs. 3 and 4 show specimens of ironbark timbers after eight months' submersion in Watson Bay, under a second test carried out by the Sydney Harbour Trust; in this case also, the untreated timbers were eaten away, whilst the treated ones were intact. Mr. Cunningham claims that the conditions under which the tests were held were more exacting than any which can be found outside the Commonwealth; they point to the obvious attack of non-treated timbers in three months and to their destruction in eight by sphaeroma gigantea, which ordinarily attain 6 ft. and frequently 12 ft. in length. The bores of these teredo are from $\frac{3}{8}$ to $1\frac{1}{4}$ in. in diameter; but another worm, which rarely exceeds 15 in. in length, bores holes up to $1\frac{3}{4}$ in. in diameter.

The process consists in impregnating timber with a hydro-carbon, and in producing a close and even charred surface on the outside by means of a high-pressure gas flame. The charred stratum is not superimposed. If any portion of this stratum gets damaged by handling in driving, the damage is made good before the timber is submerged. Knots and openings, as well as the ends of timbers, are submitted to re-impregnation and re-charring, whilst joints and checkings are but slightly charred on both surfaces so as to admit of tight fitting. The treatment can easily be applied to the bottom of lighters, punts and other craft.

A first test was laid in the Richmond River, New South Wales, in September, 1912, under the direction of Mr. E. M. de Burgh, M.Inst.C.E., Chief Engineer of Water and Sewerage. It consisted of two ironbark and two Oregon pine piles, one of each being tarred and charred in an open fire. In the following January the uncharred ironbark showed one bore. For the next few months the river was almost constantly in flood and in June, 1913, the piles were drawn, carted 25 miles and re-driven at Coraki, where the water was continuously brackish. In February, 1914, the uncharred ironbark timber was eaten through, and in the following June the remaining piles were lifted. The Board of Reference of the New South Wales Department of Works then took control of the experiments and procured sections from the timbers. When these were examined the Board considered the Oregon pine tests resultless, since the charred pile showed bare patches. The success attained with the ironbark charred timber in this first test induced the Board to recommend that the inventor should be asked to lay another test of split piles at Coraki. This was done on September 2, 1914, and in August, 1915, it was found that the untreated timbers were seriously damaged and the treated ones all intact. The latter included the ironbark pile which had stood the first test, so that its proof had extended over 32 months, or eight times the period which the first test had shown to be necessary for manifestation of attack on the untreated pile of the same timber. The Chief Engineer for Harbours and Drainage, Mr. T. E. Burrows, M.Inst.C.E., then reported that the process afforded efficient protection.

In the meantime, Mr. H. D. Walsh, M.Inst.C.E., Chief Engineer of the Sydney Harbour Trust, had instituted a test to ascertain whether the process would repel the small teredo and limnoria with which the port is infested. The timbers chosen were ironbark, box-wood and Oregon pine, and they were 10 in number. They were bolted into two balks and suspended two feet from the bottom. In eight months, two of the untreated timbers were badly holed and the third seriously attacked. The seven treated timbers, including three of Oregon pine, were all intact. After these 10 pieces had lain for six weeks on a wharf under construction, they were re-submerged, and 14 months later it was found that the treated ones were still intact, whilst those untreated were completely destroyed.

Specimens from the seaward face of one of 130 treated piles which had been three years in a jetty exposed to the wash of the ocean in an open roadstead, and from a spring dolphin in the same jetty after two years' submersion, were both intact.

The New South Wales Government has acquired the right to use the patent for its Public Works Department, including the State Railways. It is employing the process for the bridges of the North Coast Railway, extensive wharfage, road bridges, and timber spur walls laid to prevent the erosion of river banks. The Commonwealth Railway Department has treated a bridge on the Trans-continental line with the process. The Harbours and Rivers Department of the State of Victoria has adopted the invention for jetties. The Works Department of Western Australia has started operations at Cambridge Gulf, and it proposes to use the method on an extensive scale. The adoption of the process by this Department is interesting because the Engineer-in-Chief, Mr. James Thompson, M.Inst.C.E., tried open-fire charring for a good many years with results sufficiently decisive to justify the opinion that a system such as the Carbo-Teredo process, which more efficiently chars timbers and puts them in position with their treated surfaces intact, will prolong their life indefinitely.

The success which the process has achieved in the protection of timber from the destruction caused by white ants also promises a large measure of relief to countries where that evil has to be dealt with. In one instance, a piece of untreated ironbark—one of the hardest of timbers—was eaten through by white ants in four months. This test was laid in an ant nest near Parramatta, New South Wales, during the winter when termites are supposed to be almost inactive; it was carried out at the instance of the Postmaster-General of the Commonwealth. The officers of his Department were so impressed by the results, especially with regard to the probability that the process would preserve ironbark and jarrah for their natural lives, that they have laid a section of three miles of telegraph lines in New South Wales, and another in Western Australia, applying the Carbo-Teredo process and the usual poison preparation to alternate poles.

The results hitherto obtained show that the process undoubtedly affords a large measure of protection against weathering and decay. Its applicability to railway sleepers is under a test instituted by Mr. Ernest F. C. Trench, Engineer-in-Chief of the London and North-Western Railway, and the results of these trials will be of much interest.

From the economical point of view we may state that Mr. J. Davis, M.Inst.C.E., Director-General of Works, New South Wales, reports that for timber spur walls the cost of treating piles was 1·8*d.* and 2·5*d.* for round logs per lineal foot, each being 15 in. in diameter. The additional cost of round logs was due to the ends being hammered up after the first charring and then re-impregnated and re-charred. An estimate prepared by the staff of the largest public company in Australasia for 30 piles, wallings and braces and three spring dolphins worked out as follows:—Carbo-Teredo (including royalty), 77*l.* Metal sheathing, 962*l.* Ferro-concrete (piles only), 529*l.* These figures are, of course, based on the relatively higher cost of labour and material in Australasia. It should be added that the treatment of the piles by the Carbo-Teredo method was taken at 11*s.* each, which is the average for a number of works.

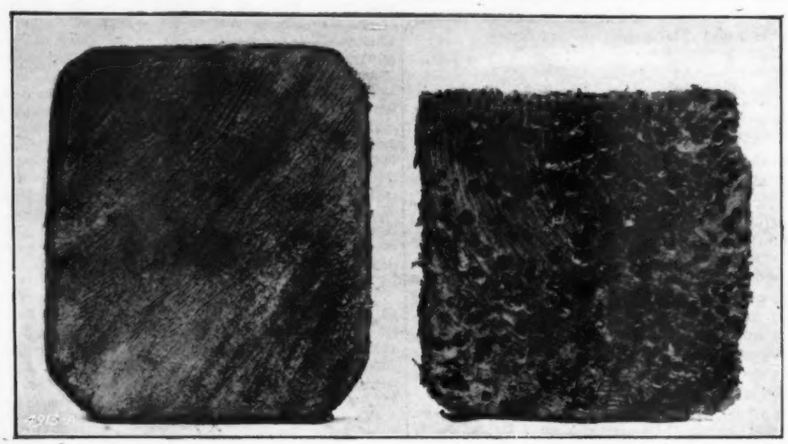


Fig. 1. Fig. 2.

Figs. 1 and 2. Treated and Untreated Oregon Pine Timbers, Pyrmont, Sydney Harbour.

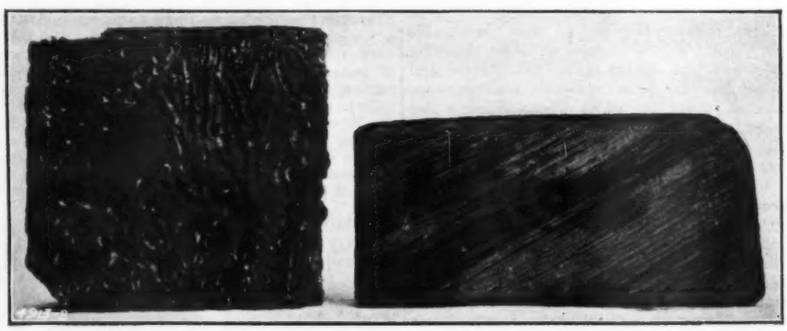


Fig. 3. Fig. 4.

Figs. 3 and 4. Untreated and Treated Ironbark Timbers, Watson's Bay, Sydney Harbour.

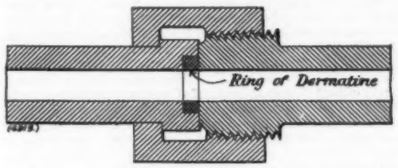
Germany's Production of Iron.—At a meeting of the Union of German Iron and Steel Industries some interesting information was given on the German production of iron during the war, as compared with that of other countries. The German production of pig-iron during 1916 may be estimated at about 13,000,000 tons, against 11,790,000 tons in 1915 and 14,380,000 tons in 1914. As regards this latter year, it should be borne in mind that whilst the production for the first seven months was exceptionally high, it was the reverse for the last five months of the year, and the figures for 1914 consequently do not afford any reliable basis for comparison. The following table shows Germany's production of pig-iron during the last 10 years:—

	Tons.
1907	13,040,000
1908	11,810,000
1909	12,920,000
1910	14,790,000
1911	15,530,000
1912	17,870,000
1913	19,290,000
1914	14,380,000
1915	11,790,000
1916 ... ... (about)	13,000,000

It will appear from these figures that the German iron industry, in spite of strenuous efforts during the war, has receded considerably from its preceding peace figures.

HYDRAULIC JOINT PACKING.

In a recent issue of the *Philosophical Magazine* the Earl of Berkeley and Dr. Burton describe a simple form of joint packing, which is, they state, tight to start with and maintains this tightness up to the highest pressures they have employed, which have attained 1,500 atmospheres, or, say, 10 tons per square inch. The annexed figure is almost self-explanatory. The pipe ends are faced, and a recess is cut in one

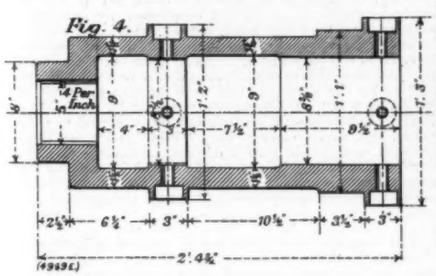


to take the ring of dermatine shown. Before assembly this stands just a little proud, and is thus slightly compressed when the joint is tightened up. Either red or black dermatine may be used, but the red, being harder, is more easily machined. The joint is said to be equally good for water or oil, and is as suitable for a flanged joint as for a screwed coupling. It is also said to be as satisfactory with large pipes as with small.

12½-IN. CENTRE HIGH-SPEED LATHES.

THE enormous influx of unskilled labour into our munitions factories has severely tested the endurance of the machine tools which they have been called upon to operate, and many tools which proved satisfactory enough in the hands of skilled turners have broken down hopelessly under the new conditions. Amongst the makers whose lathes have come with credit through this unexpected ordeal, Messrs. John Robson, Limited, of Shipley, take a high place, and we have pleasure in illustrating on the present page and page 178 two of the tools in question.

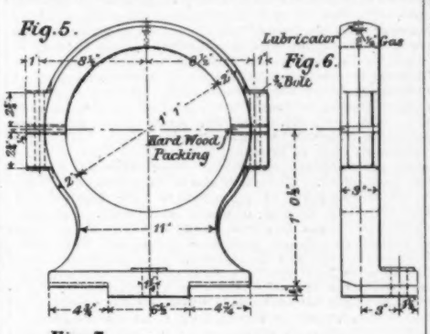
Fig. 1 represents the firm's standard pattern of high-speed lathe as slightly modified in the light of the trying experiences of the past couple of years. The machine shown has 12½ in. centres. It is of very strong construction, and has been extensively used for the production of 8-in. shells, the machinists being unskilled labourers with great physical strength and but little knowledge of matters mechanical. The fast headstock has a hollow spindle of 3½ in. bore. This runs in adjustable parallel bearings fitted with

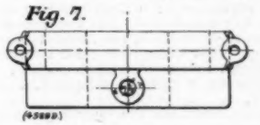


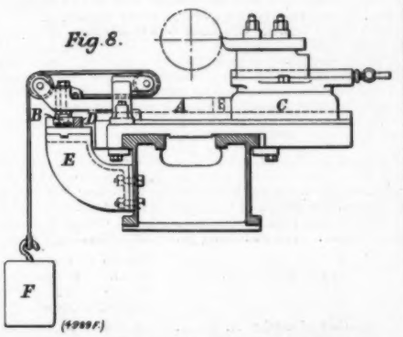
ring oilers. A four-step cone is provided, and the back gears give a reduction of 10 to 1, which in conjunction with a two-speed countershaft gives 16 speeds, ranging from 7 to 460 r.p.m. The end-thrust is taken by a ball bearing. The loose headstock is clamped to the bed by two bolts, and can be set over for taper turning. It is fitted with a large spindle having a hole from end to end. The saddle has a long bearing on the bed, and an adjustable slip is provided for taking up wear. Automatic sliding and surfacing feeds are provided, and the lathe is also fitted for screw cutting. All these feeds are instantly reversible by means of a lever on the fast headstock. All movements of the saddle are controlled from the front, and a safety device is fitted to prevent the possibility of the simultaneous engagement of the leading screw and of the ordinary feed motions. Four rates of sliding and surfacing feeds are provided, which are operated by a quick-change lever under the fast headstock. A swivel slide rest is mounted on the saddle and is fitted at option with either a square turret or the usual four-bolt tool holder.

For shell making a number of special fittings are supplied, which are illustrated in Figs. 4 to 8, annexed, The chuck used is shown in Fig. 4. This screws on to the spindle nose, which is 5 in. in diameter. The outer end of this chuck is supported in the stay illustrated in Figs. 5 to 7, which is clamped to the lathe bed. For form turning the head of the projectile the lathe is fitted with the extension slide shown at A, Fig. 8. This carries the roller B, which is held up against the former plate D by the weight F. The former D is itself fixed to the bracket E, which in its turn is firmly bolted to the lathe bed. In using this former, the cross-slide screw of the machine is disconnected, and the swivel slide turned through a right angle so that the depth of the cut can be controlled by the tool slide.

A modification of this tool is represented in Figs. 2 and 3. The height of centres is the same, but the loose head is omitted and the regular cross slide is replaced by one which carries a hexagon turret 15 in.







across the flats. A parallel push pin locates the turret in its central postion for boring operations, and indexing is accomplished by withdrawing a spring plunger, using the lever shown at the right-hand side of the cross slide, while the lever on the top locks the turret in position. The holes are 2½ in. in diameter, and a lock bolt with clamping bush fixes each boring bar in position. In addition there are four tapped holes in each face for attaching brackets if desired. As the machine is not intended for boring the solid bar the feeds range from 8 to 30 cuts per inch.

THE GIANT'S CAUSEWAY AND PORTRUSH ELECTRIC TRAMWAY.—At the annual general meeting of this undertaking, held on the 17th inst., it was stated that the permanent way and electric motive power plant had been maintained in good condition during the past year, commensurate with the diminished funds available; only absolutely necessary work was undertaken. The hydro-electric station at Bushmills was able to do all the electric traction required; the supplemental electric station at Portrush—erected in 1912—was not used at all. Owing to the war, the number of passengers carried had fallen from 155,115 in 1913 to 72,931 in 1916, and the receipts from 4,635*l.* in 1913 to 2,376*l.* in 1916. The number of miles run by electricity was 27,300—practically the same as in 1915—and again was worked at the very low figure of 2¾*d.* per mile run.

DEARTH OF RAW MATERIALS IN SCANDINAVIA.—The scarcity of countless raw materials is becoming more and more embarrassing in neutral countries. Not only are many prices rapidly approaching an absolutely prohibitive limit, but many industries either are on the verge of stopping or have already had to do so. In this connection iron and coal play an important part. Some Danish cement works have had to stop, municipal power stations and gas works are in many places "on their last legs," some large Swedish enamelled ware works have come to the end of certain materials and have to close, and both in Denmark, Sweden and Norway the telephone centrals are at their wit's end, being entirely unable to satisfy their many new subscribers, who have to wait months before they can have their telephones installed, the makers simply being unable to get raw material. In Denmark the benzine supply is now exhausted.

THE LATE MR. JAMES WALTER GRIMSHAW

WE regret to have to announce the death, which occurred at Brighton on the 15th inst., of Mr. James Walter Grimshaw, a member of the Institution of Civil Engineers. Mr. Grimshaw was born on April 19, 1852. His early studies were made in Germany, and after a short pupilage with German engineering firms he followed an engineering course at the Royal Stuttgart Polytechnic School from 1871 to 1874. From the latter year until 1877 he was in the employment of Messrs. Sharp, Stewart and Co., and of Messrs. Ormerod, Grierson and Co., Manchester; he then worked for a period at the Netham Chemical Company, Bristol. In 1877 Mr. Grimshaw entered the Harbours and Jetties Department of the South Australian Government service, and in 1880 he took a situation with the New South Wales Government Harbours and Rivers Department, where he was employed on the Sydney water supply works, in charge, first, of a portion of the canal, acting as resident engineer for the aqueducts, subsequently being in charge of the maintenance of several miles length of canal and tunnels. In the early 'nineties of last century Mr. Grimshaw originated and surveyed the proposed water supply for the city of Armidale, and supervised the completion and testing of the steel service reservoir for the Albury water supply. He was then appointed resident engineer on the Richmond River Harbour Works, when two breakwaters and training wall were under construction. Subsequently he was brought to Sydney as resident engineer over works in Sydney Harbour and South Coast District.

In Sydney he had charge of extensive wharf construction, and the conversion of Darling Island into a goods and shipping depot, cutting it down and constructing a concrete sea wall on each side for deep-water shipping, the walls being constructed with 8 and 10-ton concrete blocks. He retired from the New South Wales Government service in 1901 and has since resided in England.

IRON ORE IN GERMANY.—Owing to the great activity which prevails at the German blast-furnaces, high pressure also marks the work carried out at the German iron-ore deposits. The imports of foreign ore having been much hampered by the war, home supplies have to be relied upon, assisted to a large extent by ore supplies from the occupied Briey districts in France. Nearly the whole production for the current year of the Nassau district has been disposed of at rising prices; the maximum price of 25 marks fixed for these ores has been exceeded, sales having been effected at 28 marks per ton. The Siegerland Iron Ore Union is selling for 1917 at prices 5 to 7 marks higher, which increase was conceded only after long negotiations. Several long-term contracts at low prices have, in the meantime to stand over.

THE INSTITUTE OF METALS.—The annual general meeting of the Institute of Metals will be held in the rooms of the Chemical Society, Burlington House, Piccadilly, on Wednesday, March 21, and Thursday, March 22. The meeting will commence at 8 p.m. on the first day and at 4.30 p.m. on the second day. A special feature will be a general discussion on metal-melting, a subject which has now assumed national importance, since vast quantities of fuel, solid, liquid and gaseous, are used in metal-melting, particularly for munitions making. In regard to this point the Institute is very fortunate in having as its president, who will take the chair at the discussion, Sir George Beilby, LL.D., F.R.S., the head of the new Government Board on Fuel Research. The following papers are expected to be submitted in the order given:—(*a*) At the meeting on March 21: (1) "The General Properties of Stampings and Chill Castings in Brass of Approximately 60/40 Composition," by Owen W. Ellis, B.Sc. (London); (2) "Machining Properties of Brass," By Owen W. Ellis, B.Sc. (London); (3) "Surface Tension and Cohesion in Metals and Alloys," by Sydney W. Smith, B.Sc., A.R.S.M. (London); (4) "Aluminium Production by Electrolysis: A Note on the Mechanism of the Reaction," by R. Seligman, Ph.Nat.D. (London); (5) "Annealing of Nickel Silver (Part II)," by F. C. Thompson, D.Met., B.Sc. (Sheffield) (subject to being completed in time). (*b*) At the meeting on March 22 (general discussion on metal-melting): (6) "Metal-Melting as Practised at the Royal Mint," by W. J. Hocking (London); (7) "Coal Gas as a Fuel for the Melting of Non-ferrous Alloys." by G. B. Brook (Sheffield). (8) "High-Pressure Gas Melting," by C. M. Walter, M.Sc. (Birmingham); (9) "Contribution to Metal-Melting Discussion," by H. M. Thornton (London) and H. Hartley, M.Sc. (London); (10) "An Electric Resistance Furnace for Melting in Crucibles," by H. C. Greenwood, D.Sc. (London), and R. S. Hutton, D.Sc. (Sheffield); (11) "Ideals and Limitations in the Melting of Non-ferrous Metals," by Carl Hering (Pa., U.S.A.); (12) "Metal-Melting in a Simple Crude Oil Furnace," by H. S. Primrose (Ipswich). On account of Caxton House having been commandeered by the War Office, the address of the Institute of Metals will in future be 36, Victoria-street, S.W. The seventh annual May lecture of the Institute will be given at the Institution of Civil Engineers, on Thursday, May 3, 1917, at 8.30 p.m. by Professor W. E. Dalby, M.A., F.R.S., on "Researches made possible by the Autographic Load Extension Optical Indicator."

NATIONAL INSTRUCTION IN TECHNICAL OPTICS.

On October 12, 1916, the Board of Scientific Societies appointed a sub-committee, consisting of Mr. Conrad Beck, Mr. F. J. Cheshire, Mr. E. B. Knobel, Sir Philip Magnus, Professor H. Jackson and Professor A. Schuster, to report on national instruction in technical optics. Their report has now appeared. In it there is enumerated the means which already exist for the training of operatives and others in connection with technical optics, including the chemical composition and manufacture of glasses. There are classes held at the Northampton Polytechnic Institute, where a certain amount of modern machinery and apparatus has been provided. Research work is being carried out in King's College, London, under the Glass Research Committee of the Institute of Chemistry. The London County Council has a carefully considered scheme to utilise and extend the teaching given in existing institutions and to reconcile conflicting interests. According to that scheme the Imperial College of Science should institute a separate department for technical optics, with a head who is also to exercise some undefined powers of general supervision over the whole scheme. Post-graduate work, following upon the work of the Northampton Institute, would be conducted at the Imperial College, and the teachers in any institution which may be built, or, during the transitional period, of the Northampton Institute, should be of sufficient standing to be able to conduct research work. The committee now suggest that it is desirable to contemplate the establishment of an Optical Institute which should concentrate the efforts of all who are concerned with the manufacture or use of optical instruments. This institute would bring together the several optical societies, who might find a home within its building. It would be the centre for the co-operation of the trade with students and teachers, and it should contain a library, and periodicals and books on optics. The general direction of the courses of study should be vested in an advisory council, on which the trade, as well as the optical and learned societies, would be represented. There should be a principal or director, highly qualified both on the theoretical and practical side, who would be responsible to the advisory council. Full courses of instruction, both in day and evening classes, would be required. The day departments would consist mainly of youths between the ages of 15 and 20 years, who would receive general and technical instruction, including mathematics, physics, chemistry and practical optical work. The evening work would be adapted to the requirements of: (1) students engaged in the trade during the daytime, (2) advanced students preparing to occupy the position of managers in optical works, and (3) all other persons interested in learning the scientific construction or use of optical instruments. Among the duties specially assigned to the director in the preliminary period would be that of advising the trade in any difficulties they may encounter; a sufficient staff should be assigned to him for the purpose. Pending the carrying out of this scheme, the immediate requirements are laid down as: (1) the appointment of a supervising representative council, (2) the appointment of an administrating director, (3) the translating of suitable works on technical optics, and (4) the organising of day and evening courses at the Northampton Institute, and arrangements for higher instruction in some other institution of university rank. This report was approved by the Board of Scientific Societies on January 24.

Mechanical Difficulties in the Evolution of the Steam Turbine: Errata.—Mr. Gerald Stoney informs us that we were in error in attributing to him, in the article published on page 157, the plan of using fine fins on one of two adjacent surfaces in rapid relative motion. The credit is really due to Sir Charles Parsons, and, as is well known, the device in question solved a very serious problem in turbine construction. On page 158, column 3, near the middle, for "32 per cent. nickel steel" read "30 per cent. nickel."

The German Coal-Mining Industry.—Expansion continues to be the order of the day within the German coal-mining and kindred industries, and some interesting moves are at present going on. These refer to the Gewerkschaft Trier I, II, III, and Hermann I, II, III, of which the powerful Gelsenkirchen Mining Company is stated to be endeavouring to secure the majority, say, two-thirds, if not the totality, of the "Kuxes" (mining shares). The Gewerkschaft in question is divided into 3,000 such shares. The Gelsenkirchen Company, which is being ousted from its position at the head of the list within the Rhenish-Westphalian Coal Syndicate by the Prussian Crown, owing to the latter's acquirement of the Hibernia shares, is anxious to regain her old premier place. In the temporary syndicate the Gelsenkirchen had an allotment of 9,995,700 tons of coal, 1,826,808 tons of coke, and 216,000 tons of briquettes; the allotment in the new syndicate is based upon the same figures, besides 2,085,000 tons for home consumption, as against 12,628,500 tons of coal, 3,612,800 tons of coke, and 66,350 tons of briquettes for the Crown. The allotments of Trier I and II commence at 550,000 tons of coal, rising to 1,000,000 tons; whilst the Trier III Gewerkschaft begins with 1,200,000 tons of coal, rising to 1,500,000 tons in 1921, besides 410,000 tons of coke. The highest aggregate in coal for Trier I, II, III, is consequently 2,500,000 tons, besides 410,000 tons of coke, whilst the coal allotment for the Hermann Gewerkschaft begins at 750,000 tons and rises to 1,000,000 tons, besides 500,000 tons of coke. The two concerns, consequently, would again place the Gelsenkirchen Company at the top in the matter of coal allotment before the expiration of the new syndicate.

THE ROYAL METEOROLOGICAL SOCIETY.

The usual monthly meeting of this society was held on Wednesday, the 21st inst., at the society's rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., president, in the chair. Mr. W. H. Dines, F.R.S., read a paper on the "*Heat Balance of the Atmosphere.*" The paper traces as far as may be the history of the solar radiation from the time it reaches the outer limit of the atmosphere until it is radiated back into space, assigning from the data available limits to the amounts absorbed, transmitted and reflected by the air, and to the amounts mutually radiated between the earth, the air and outer space. A note is added showing that a "gray" body in the position of the upper air should have a temperature of about 300 deg. C.

Mr. C. E. P. Brooks, M.Sc., also read a paper on "*Continentality and Temperature.*" The distribution of temperature over the surface of the earth is complex, being related to various factors—latitude, height, distance from the sea, &c. Further, since even smoothed isotherms reduced to sea-level often show very little relation to lines of latitude, it is evident that in some cases geographical conditions must exercise a predominant effect. This effect was investigated in the case of the distribution of temperature over Europe and Western Asia during January and July. Fifty-six representative stations were selected, and by the method of partial correlation regression equations were constructed showing how the temperature of any place in the area may be built up from its height, its latitude and the percentage of land in the area surrounding it. The function taken to represent latitude was the quantity of heat which would be received on a horizontal surface with a transmission coefficient of 0.7, on the shortest day and the longest day respectively (the last proviso allowed a lag of about three weeks in the thermal effect of the sun's radiation). That this gives a good measure of heat received is shown by the correlation coefficient of + 0.944 found between it and the temperature in January.

From these regression equations the temperatures of the original stations were calculated, and over a range of 50 deg. F. in January the average error was found to be about 4 deg.; in July the error was much less. Finally, the equations were applied to the altered geography of the early Neolithic period, and it was found that this entirely accounted for the altered climate of that period, and the various astronomical theories which have been brought in to explain it are quite unnecessary.

Labour in Japan.—The law which is to be put in force in a few months' time in Japan with a view to protecting the working class, says the *American Machinist*, has caused the Board of Industry to investigate the total number of men and women employed in industry at the present time. The following gives the official figures:—

	Works with Prime Mover.	Works without Prime Mover.
Number of works	14,578	17,139
Number of men employed...	274,030	109,927
Number of women employed	469,013	95,291
Total number of operatives	743,043	205,218
Average operatives per works	51	12

Ammonia Pump Rods.—The life of piston rods in ammonia pumps is comparatively short, the packing has frequently to be renewed to prevent leakage of ammonia, and the renewal itself involves loss of ammonia. Mr. D. L. Fagnan (*Power*, November 14, 1916) addressed inquiries to operators, and was informed by 25 operators that they had to repack the rods every three weeks and to renew them every three months, and the reports from ammonia pump manufacturers corroborated these statements. Experimenting with different pump-rod materials, he found, however, that high grade tool steels, provided with a fibrous packing symmetrically arranged about a central insertion of babbitt metal, will wear well. One of these rods had been running a year—18 hours per day in summer and six to eight hours in winter—and the wear was only 0.002 in. The rod is kept lubricated by five or six drops of oil per minute, and the smell of ammonia was only noticed when a new rod was started.

Coke as Motor Fuel.—In the case of the road locomotive the partial abandonment of coke as fuel can be traced to the Heavy Motor Car Order of 1904, limiting the tare weight of vehicles to 5 tons. To comply with the regulations, designers were obliged to cut down weight by curtailing fire-box dimensions to the lowest practicable limits. In order to realise the rated capacity of their wagons having such restricted grate area, the use of coke had to be abandoned and the more concentrated and expensive coal fuel became necessary. In various present-day locomotive type wagons the maximum average hourly rate of fuel combustion may reach 45 to 50 lb. per square foot of grate, at which rate the average evaporation realised, as shown by various statements of coal and water consumption, is only some 6 to 7 lb. of water per pound of best quality Welsh coal. From the national economic standpoint it is to be hoped that the authorities charged with the framing of the new road-traffic regulations will take due cognizance of the disadvantages of the present conditions.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—With the production of war work still taking first place, steel makers are finding it increasingly difficult to undertake any ordinary mercantile business at all, even were it possible to get the material to do so. For many months now the menace of freight and transport has been so overwhelming as practically to preclude any supplies of raw material coming into the country. With characteristic foresight, therefore, makers have endeavoured "to make good" without the imports upon which they depended so greatly, even in the earlier days of the war. The effect of this scarcity has been that discard steel is being used for any business that can be put through, other than war work. In some cases even iron is being used and for this no export licence is required. All the same, the demands of the British and the allied Governments are so very pressing that there is little opportunity of anything beyond these being attempted. The entire plant available runs unceasingly, and the output of steel bars for shells is heavier than ever and more urgently required. For export, prices are nominal—ship-plates, 14*l.* 10*s.* per ton; boiler plates, 15*l.* 12*s.* 6*d.*, or thereabouts; and angles, 14*l.* 5*s.*

Malleable Iron Trade.—Malleable ironmakers can now, more than ever, make their own terms, both in regard to the work they undertake and the price to be paid for it. Except in very limited quantity they are not in a position to quote for practically anything that is not required, directly or indirectly, for the purposes of war, and if quick delivery is desired they may almost charge any figure they like. Indeed, even the price of 15*l.* per ton, the current rate for "Crown" bars, is frequently exceeded, the reason being the scarcity caused by so many of the mills being used, in these days of heavy pressure, to roll steel instead of iron.

Scotch Pig-Iron Trade.—At the moment, pig-iron is produced in quantity and instantly absorbed, this hand-to-mouth method suiting producers at a time when the accumulation of stock is an absolute impossibility. The steel works continue to swallow up the entire output of hematite as soon as it is available for use, and the demand shows no sign of diminishing. Except when required for the Allies it is not possible to obtain either hematite or foundry iron for shipment. Indeed, even for the home requirements the supply of foundry grade is in no way equal to the demand. Prices are virtually on the same level as a week ago.

Dangers of Shipping Nationalisation.—Speaking in support of the adoption of the report of the Glasgow Shipowners' Association, moved by Lord Inverclyde at the annual meeting on Wednesday last, Mr. Robert Clark made very direct reference to the nationalisation of shipping, pointing out various difficulties which presented themselves to him. In his opinion the nationalisation of shipping was an entirely different matter from the nationalisation of railways, as, the railways being situated within the bounds of the country, complete control was possible, while the same conditions could not be said to apply to shipping, owned and controlled by individual enterprise without any State aid whatever, and subject to keen competition both at home and abroad, particularly from foreign owners. Under these conditions the nationalisation of British shipping would be a very serious matter for the owners if this were done at rates which would give but an inadequate return. If, as is most likely, the war should be followed by a period of poor trade, this would mean a very "lean" time for shipowners, and would give a decided advantage to their foreign competitors, whose profits would increase as the others decreased. The matter is one which Mr. Clark considers should be dealt with promptly and seriously.

The German Steel Union.—It appears to have been the question of the inclusion of the "B" products—a moot point of old standing—which caused the renewal of the Steel Union to be limited to one year, instead of being carried over two. It was again Herr Thyssen who caused difficulties in this respect, as he declined to go beyond the one-year prolongation unless the "B" products also formed part of the arrangement. Although the time is far from favourable for such a move, the syndicalising of the "B" products, in spite of all previous failures in this direction, has to be taken up afresh and on the lines set forth by Herr Thyssen. This means that the "B" products may have to pass within the province of the Steel Union, and the question will have to be solved in a more decisive form than what obtained at former allotments. The negotiations were to begin on February 6, but people are rather sceptical as to the result.

The Control of British Canals.—An important regulation dealing with the control of canals by the Board of Trade is given in the *London Gazette*. It provides that where the Board of Trade are of opinion that it is expedient that this regulation should be applied to any canals, the Board may by order apply the regulation either generally to all canals or to the canals in any special area, or to any special canals. Any canals so affected shall pass into the possession of the Board, and the owner, managers, or workers shall comply with the directions of the Board of Trade as to the management and uses of the canal. The term "canal" includes all buildings, barges, machinery and canals. It is stated that the Board of Trade are about to make an Order under the new regulation taking possession of such of the non-railway owned canals as are required for essential traffic. They propose to appoint an executive committee to control the canals on their behalf.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The burning topic of the day with the distributors is that of carting. There are many indications that the days are not far distant when the exigencies of the military situation may require a tightening up of the exemptions granted to fit young carters. Such a probability is viewed with dismay by the dealers and merchants, for even to-day there is no surplus of carters, as the military authorities have been informed in the recent informal conference. What the outcome of the whole matter will be it is difficult to forecast, though it is hard to believe it is intended to cripple a branch of the transport service of so essential a character. The general position reveals few new features. There is still a great scarcity of supplies of all grades. Manufacturing fuel deliveries are just sufficient for immediate needs and stocks at works have now reached a very low state. Bad working of railway traffic has disorganised the coal trade. Several pits have been standing idle for days together owing to the non-arrival of empty wagons. The position is serious and wants prompt handling. House coal sorts are coming to hand very slowly. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at pit.

Iron and Steel.—Few items of outstanding interest have arisen during the week. The greatest object of the day is to increase the existing standard of production, as the pressure of orders is applied with ever-growing intensity. Makers of steel, tools, files, saws and railway work are in particular severely pressed, but the bulk of their output is entirely for war purposes. The chances of orders for other classes of work being executed in the face of present conditions are exceedingly remote. The production of direct munition work is stated on good authority to be cause for entire satisfaction and confidence. The heavy steel shops are in urgent need of strong men able to perform laborious work for long periods, but they are hardly getting the type they require. High-speed steel and tool manufacturers are introducing more female workers, with eminently good results. It is again of interest to note the position of the agricultural engineers. Their work is now almost on the same plan as statutory war work. A short time ago the leading Sheffield makers were withholding their production upon the ground that permits were necessary before agricultural implements and machinery could be bought and sold. Such is not now the case, for the air has become clarified by an instruction of the Agricultural Machinery Branch of the Ministry of Munitions. In this it is stated that distributors do not require permits to purchase or sell the goods. The maker is free to produce all he can get steel for, and this material will be vouchsafed him under the general covering permit he already possesses. Southend Corporation has accepted a Sheffield tender for tramway tyres. War Office and Admiralty departments require huge parcels of tools. Other contracts include 2,000 sawyers' wedges, 300 dough-mixing knives, 6,000 spokeshaves, 1,500 Scotch tinmen's shears, 3,000 snips, 5,000 carpenters' drawing knives, 300 smiths' stock shears, 8,000 oilstones, and 25,000 nippers and pliers. Overseas trade maintains excellent proportions. The latest indents are for tools, knives, saws, files, sheep shears, augers, anvils, steel castings, steel, cutlery and plate.

Messrs. Henry Bessemer and Company, Limited.—The annual meeting of this firm took place at Sheffield on the 19th inst., when it was decided to pay a final dividend of 10 per cent., making 12½ for the year, free of tax. The meeting was in many respects formal, for the company's liabilities under the Munitions of War and the Finance Acts have not yet been determined, and a balance-sheet could not be presented. Sir Charles Allen, who was re-elected chairman, pointed out, however, that the year had been eminently satisfactory, and, so far as could be ascertained, the profits were slightly better than those of the preceding year. They did, in fact, so nearly correspond to those, that the directors had decided upon the course of recommending the payment of the same amount of dividend. As the firm had been under Government control, they had not been altogether their own masters, but they had not suffered in consequence of that. Their trouble had not been a want of work, but the want of facilities for executing all that had come their way. He was afraid that their difficulties in this direction would be increased in the coming year. They had commenced 1917 well. They had plenty of orders, and he trusted that they would have an excellent report of the trade done when the next annual meeting came round.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report concerning Cleveland pig-iron. The situation, on the whole, may be described as satisfactory, for whilst, for the time being, there is something of a lull in business, home consumers at present having all the iron they require, there is reason to believe that in the near future demand will be good. There are still occasional allocations for this month, and the distributions over March promise to be on a rather extensive scale. Makers and consumers continue to favour forward business, and some negotiations are still proceeding for delivery to the end of June, subject, of course, to any official alterations in prices. Export trade is fairly good, though still handicapped by the tonnage situation. For home consumption No. 3 and No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; whilst for despatch to our Allies No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for shipment to neutral countries the minimum prices named are 105*s.* for No. 3 and 110*s.* for No. 1. Though business with neutrals is difficult to arrange a few inquiries on behalf of customers in neutral countries continue to be reported.

Stocks of Cleveland Pig-Iron.—Makers have very little Cleveland pig-iron lying at their yards, and the quantity in the public warrant stores is still being drawn upon, three withdrawals of No. 3, totalling 452 tons, having been recorded so far this month, thus reducing the stock in the warrant stores to 2,296 tons, composed of 2,260 tons of No. 3 and 36 tons of other kinds of iron deliverable as standard.

Hematite Iron.—With regard to East Coast hematite iron, supply is such as adequately to meet all home requirements and leave quite considerable quantities available for export, with the result that business is being put through more freely, especially as permits for shipment to our Allies are less difficult to obtain than they have been. Further sales to our Allies are understood to have been made. Values are well maintained. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Pig-Iron Shipments.—Though not heavy, shipments of pig-iron from the port of Middlesbrough are on a satisfactory scale. So far this month they amount to 31,711 tons, as compared with 16,949 tons to the same date last month, and 29,916 tons for the corresponding part of February last year.

Coke.—Demand for coke continues good for local consumption, and fixed maximum prices are rather readily paid. Average blast-furnace sorts are 28*s.* at the ovens, and qualities low in phosphorus 30*s.* 6*d.* at the ovens.

Foreign Ore.—Considerable quantities of foreign ore are still coming steadily to hand, and some consumers have large stocks. Unloadings at the port of Middlesbrough to date this month are officially given at 119,342 tons.

Manufactured Iron and Steel.—Finished iron and steel manufacturers are very busily employed, and continue to add to their already huge output. Government work continues to absorb most of their time, but despite claims for delivery of other descriptions, production of material for mercantile shipbuilding material, which has now assumed very large proportions, is still steadily increasing. Prices are very stiff. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 12*l.*; and packing iron and steel (tapered), 14*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

Coalfield Labour Position.—There has been a good deal of stir in the South Wales coalfield during the past week. A conference of delegates representing the Welsh miners had rejected the scheme agreed upon between the Government and the Miners' Federation of Great Britain for combing-out colliery workers for the army. An adjourned sitting took place on Monday, but in the mentime much excitement prevailed, it being feared that the incident would lead to another untoward state of affairs in the coalfield. The men's leaders were nonplussed by the rejection of the scheme, and there were many misgivings as to the upshot. Two factors had contributed to the rejection of the proposals. The first was the pacifist element which is fostered by a certain section of the local leaders, and the other is the irregularity of work now being experienced, particularly in the anthracite area. Fortunately, at the adjourned sitting, consequent, no doubt, upon the strenuous efforts made by the more responsible leaders, the previous resolution was rescinded by nearly the same majority as it was previously carried. This, therefore, marked the close of a most unpleasant and disconcerting episode.

The Coal Markets.—The coal market is quieter and weaker than ever. Shipping is coming along very slowly and is insufficient to keep all the pits in the coalfield working regularly. So far the higher freight offered to neutrals for the employment of ships in the allied trades has not attracted tonnage, and consequently stocks have accumulated, and coals of all grades, with the exception of superior Admiralty large, which is monopolised by the authorities, are in abundant supply and for prompt shipment obtainable at several shillings below the limitation prices of 30*s.* for large and 20*s.* for small. The inquiry is very slow, and second Admiralty, Western Valleys and Black Vein large have all been sold at 24*s.* 6*d.*, good Eastern Valleys from 23*s.* to 24*s.*, with the cheaper qualities down to 21*s.* 6*d.* Small steams have been in abundant supply, and even the best bunker descriptions were securable at 15*s.* 6*d.*, good cargo sorts 12*s.* 6*d.*, and the inferior cargo classes from 9*s.* Bituminous coals for export have been practically unsaleable, with No. 2 Rhondda large worth no more than 23*s.*, throughs 18*s.*, and smalls 15*s.* At Swansea the tonnage shortage has also checked inquiries very materially, and in anthracites best malting large has been obtainable at 26*s.*, nuts at 33*s.*, and machine-made beans at 23*s.* 6*d.* Steam coals were round 24*s.* 6*d.* for best large and 12*s.* for smalls. The inquiry for patent fuel has also been slow, and buyers with prompt boats have been able to secure supplies down to 2*s.* 6*d.* under the limitation price of 30*s.* Pitwood remained as scarce as ever, and the price has advanced from 70*s.* to 75*s.*

Bute (Cardiff) Docks Trade.—The official returns of the trade of the Bute (Cardiff) Docks show that in 1916 imports and exports amounted to 11,084,296 tons, against 11,433,506 tons in 1915 and 13,676,941 tons in the record year of 1913. Exports alone were 9,380,497 tons in 1916, against 9,632,811 tons in 1915 and 11,605,641 tons in 1913, of which coal and coke accounted for 8,634,234 tons, compared with 8,934,275 tons and 10,576,506 tons in 1915 and 1913 respectively. Imports last year totalled 1,703,799 tons, against 1,800,695 tons in 1915 and 2,071,300 tons in 1913, of which iron ore amounted to 616,668 tons, against 628,636 tons and 746,381 tons in 1915 and 1913 respectively. The number of vessels cleared from the Bute Docks in 1916 totalled 3,003 of 5,524,794 registered tons, against 8,207 vessels of 5,709,253 tons in 1915 and 8,980 vessels of 6,167,933 tons in 1913. Last year 6,579 steamers of 5,362,819 tons were cleared, against 6,769 of 5,502,996 tons in 1915 and 7,758 steamers of 6,004,615 tons in 1913.

Financial News.—The profits of the Globe Shipping Company for 1916 amounted to 28,565*l.*, after providing for excess profits duty, and the dividend is 25 per cent. for the year, less tax.—The net income of Consolidated Cambrian, Limited, in 1916, was 14,060*l.*, and the dividend for the year 10 per cent., with a bonus of 5 per cent.—The profits of Graham's Navigation (Merthyr) Collieries, Limited, in 1916, amounted to 23,358*l.*, and the dividend is 15 per cent. for the year, against 12½ per cent. in 1915.—The profits of the Penarth Pontoon, Slipway and Ship Repairing Company, Limited, in 1916 amounted to 17,450*l.*, after provision for duty under the Finance and Munitions Acts, and the dividend is 10 per cent., against 6 per cent. in 1915.—After provision for excess profits duty, &c., the profit of the Cardiff Collieries, Limited, in 1916 amounted to 73,986*l.*, and the dividend on the ordinary and preference shares is 20 per cent. for the year, against 15 per cent. in 1915.—The managers of the Western Counties Shipping Company, Limited, have declared an interim dividend of 6*d.* per share, less tax.—The net profits of D. Davis and Sons, Limited, after deducting fixed charges, amounted to 246,364*l.* in 1916, and the dividend for the year is 20 per cent., which with the bonus of 10 per cent. in September, makes 30 per cent. for the year, against 10 per cent. in 1915.—The profits of the Redcroft Steam Navigation Company, Limited, for the year ended January 31, 1917, are 73,796*l.*, after provision for excess profits duty, and the dividend is 10 per cent. for the year, together with a bonus of 10 per cent.—The receipts of the Alexandra (Newport and South Wales) Docks and Railway in 1916 amounted to 438,464*l.*, and the expenditure to 293,932*l.* The dividend on the "A" and "B" preference stocks is at the full rate of 4½ per cent.—The directors of Insoles, Limited, have declared an interim dividend at the rate of 10 per cent. per annum for the half-year ended December 31, 1916.—The Haenton Steam Shipping Company, Limited, made a profit on the trading and sale of their two steamers in 1916 of 7,278*l.*, and interim dividends paid equal 20 per cent. for the year.—The Albion Steam Coal Company, Limited, made a profit in the year ended December 31, 1916, of 49,576*l.*, and the dividend is 5 per cent. on the ordinary shares, after paying 2½ years' preference dividend to June 30, 1916, and it is proposed to pay the half-year's dividend on the preference shares to December 31 last at the rate of 6 per cent. per annum. This is the first dividend paid on the ordinary shares since 1908.

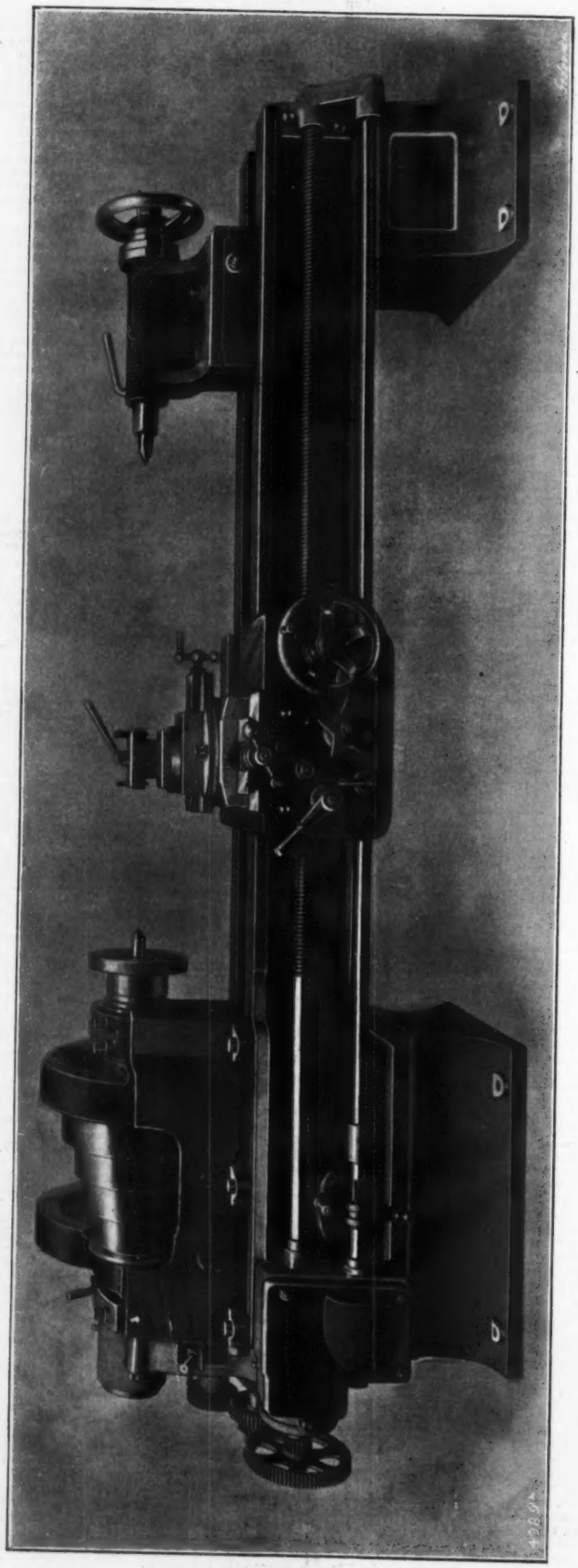
CEMENT DESTRUCTION IN MOORLAND.—Cement foundations of buildings are endangered not only by free sulphuric acid, but also by the soluble sulphates of calcium and magnesium. According to W. Thörner, peat soils contain only small and harmless amounts of these sulphates; moorlands near the sea may, however, be richer in them. The reason of the destructive action of the soluble sulphates is, according to H. Kühl—compare *Zeitschrift für Angewandte Chemie*, 1916, pages 335 and 363, for both these papers—that a voluminous compound of the formula $3CaO,Al_2O_3,3CaSO_4$ (Candlot and Michaelis) is formed, when soluble sulphates penetrate into cements, whose sulphate percentage was originally unobjectionable.

CONTROL OF TIMBER.—Sir Bampfylde Fuller, K.C.S.I., has undertaken charge of the Department of the War Office which is dealing with: (1) The supply of timber for the use of the Army; (2) the control of the use of timber in the United Kingdom, with a view to effecting economy in its use for all purposes; (3) the regulation of the purchase of such timber as may be imported from sources outside the United Kingdom, whether on Government or private account; (4) the stimulation of the felling of timber in the United Kingdom. His office is Caxton House, Tothill-street, Westminster, S.W., and all communications on the subject should be addressed to him there. He will be assisted by an advisory committee consisting of four or five timber merchants chosen by the Timber Federation, and by one or two other gentlemen representing firms of repute which do not belong to the federation.

12½-IN. HIGH-SPEED LATHES.

CONSTRUCTED BY MESSRS. JOHN ROBSON (SHIPLEY), LIMITED, ENGINEERS, SHIPLEY.

(*For Description, see Page* 175.)



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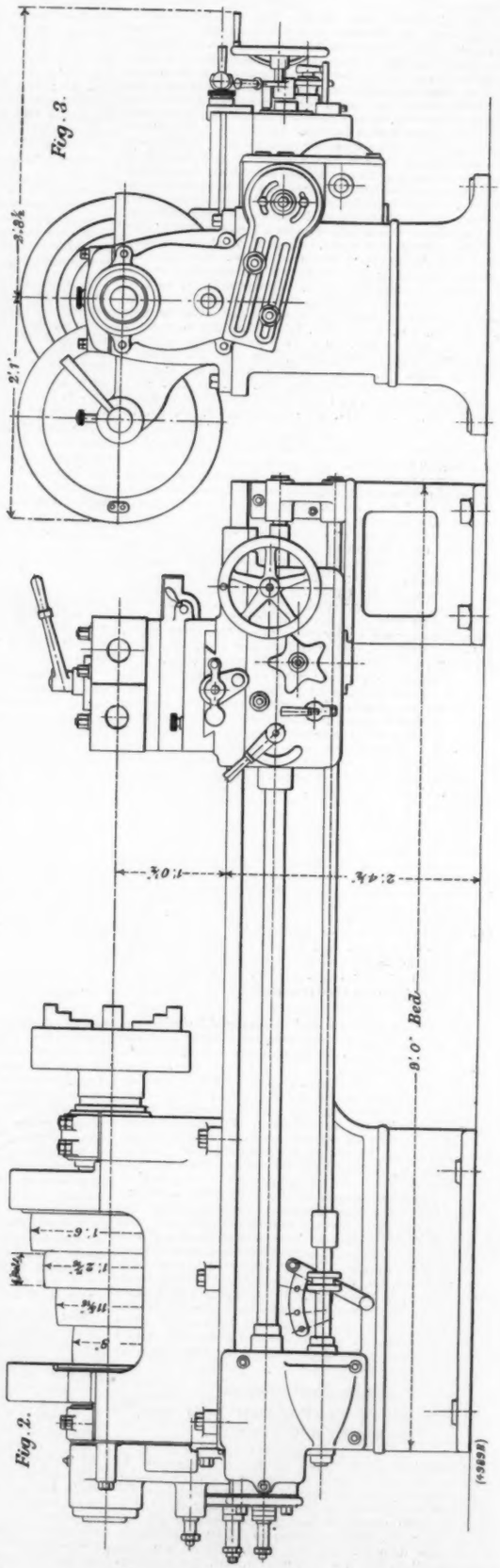


THE RECONSTRUCTION OF THE OLDHAM-ROAD GOODS STATION, MANCHESTER; LANCASHIRE AND YORKSHIRE RAILWAY.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE L. AND Y. RAILWAY.

(*For Description, see Page* 169.)

FIG. 11. ONE OF THE BAYS IN THE TRANSHIPMENT BUILDING.

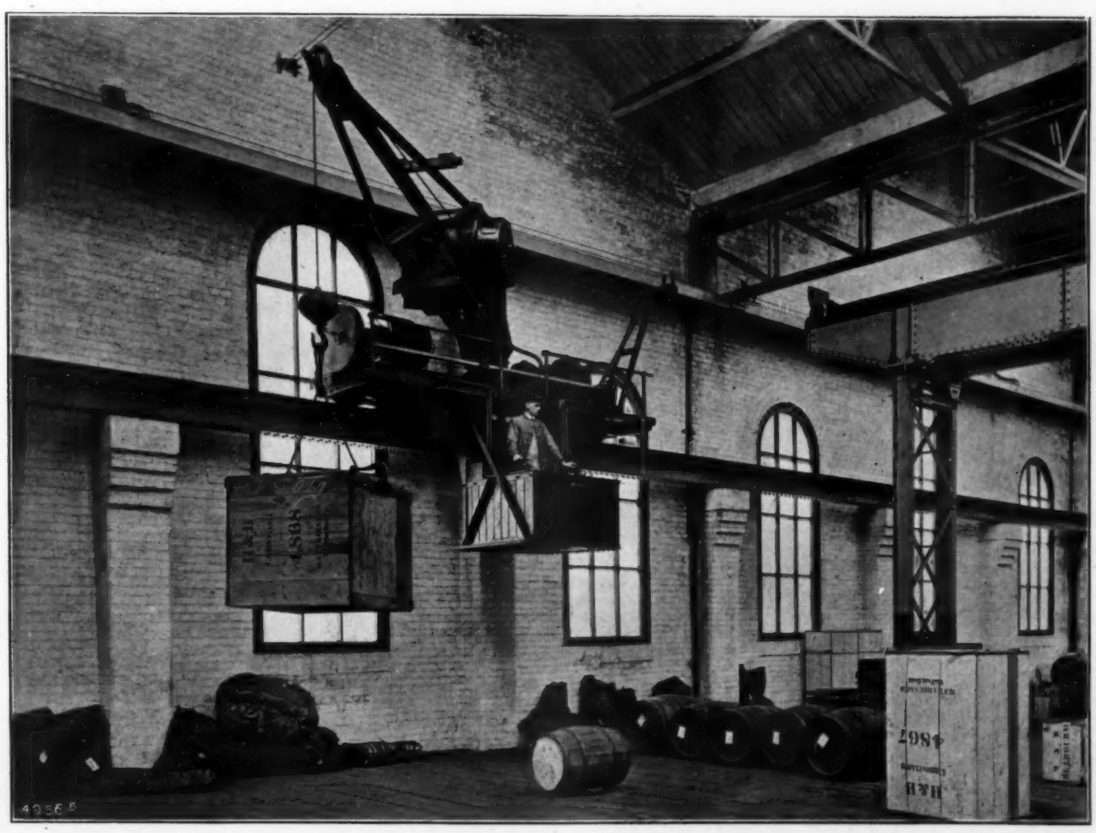


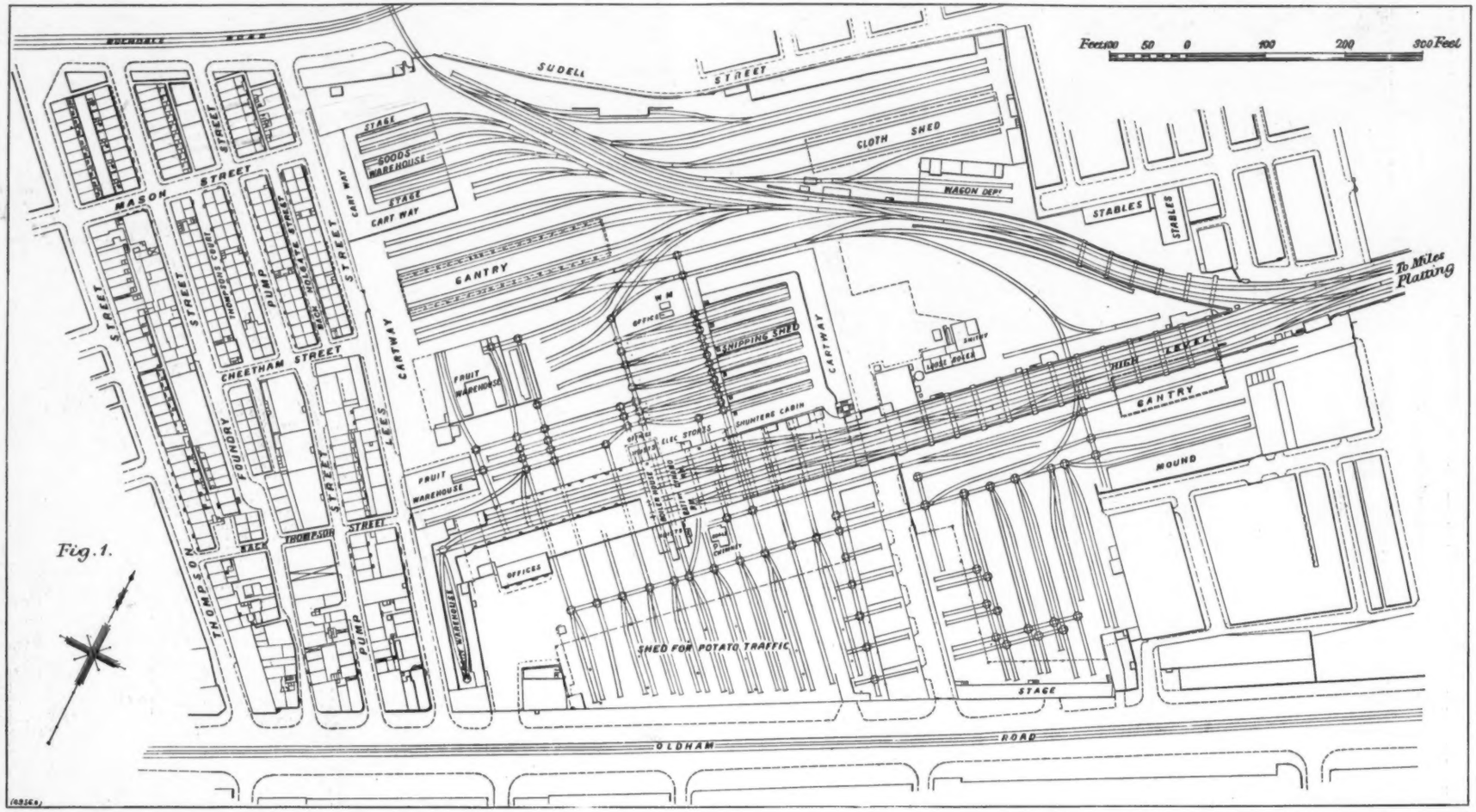
FIG. 12. MONO-RAIL JIB CRANE IN THE TRANSHIPMENT BUILDING.

(*To face page* 170.)

THE RECONSTRUCTION OF THE OLDHAM-ROAD GOODS STATION, MANCHESTER; LANCASHIRE AND YORKSHIRE RAILWAY.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE LANCASHIRE AND YORKSHIRE RAILWAY.

(*For Description, see Page* 169.)



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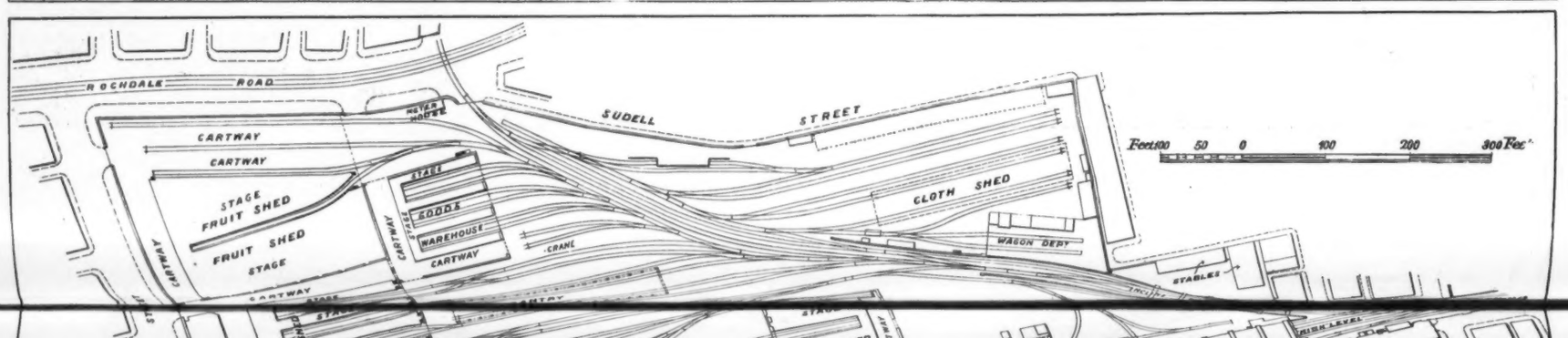
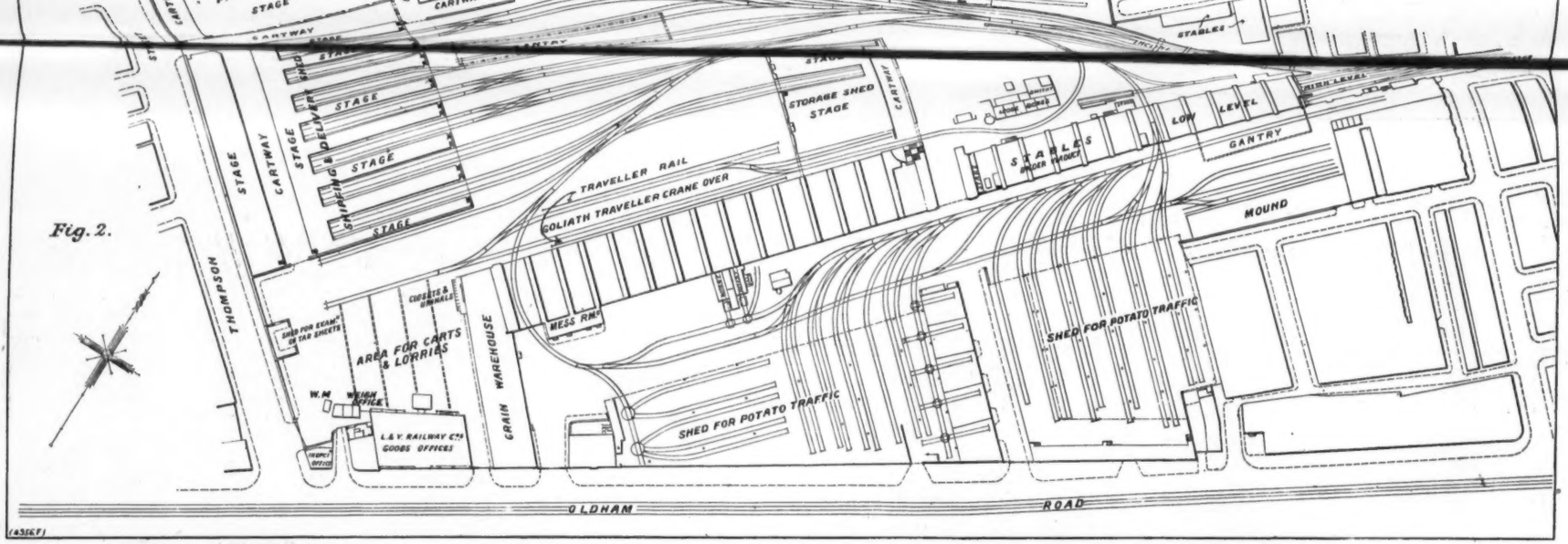


Fig. 2.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THE RECONSTRUCTION OF THE OLDHAM-ROAD GOODS STATION, MANCHESTER; LANCASHIRE AND YORKSHIRE RAILWAY.

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(*For Description, see Page* 169.)

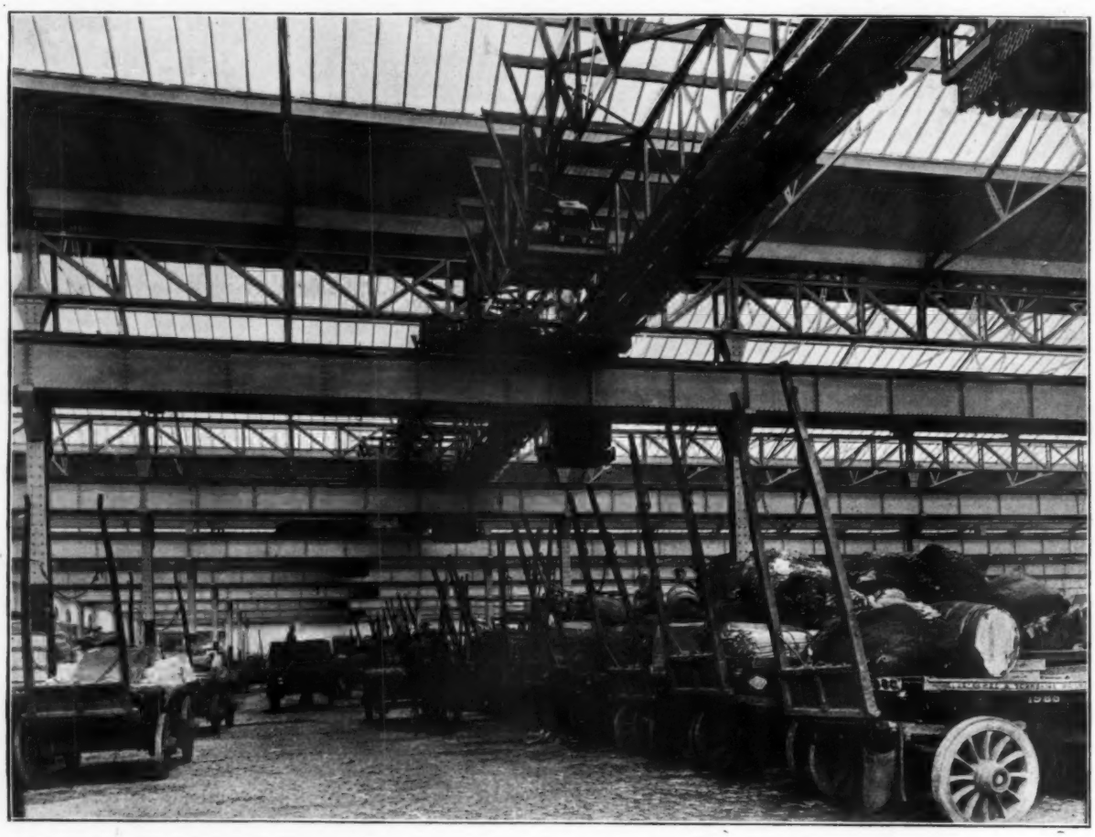

FIG. 13. CARTWAY IN TRANSHIPMENT BUILDING, WITH 30-CWT. OVERHEAD ELECTRIC CRANES.

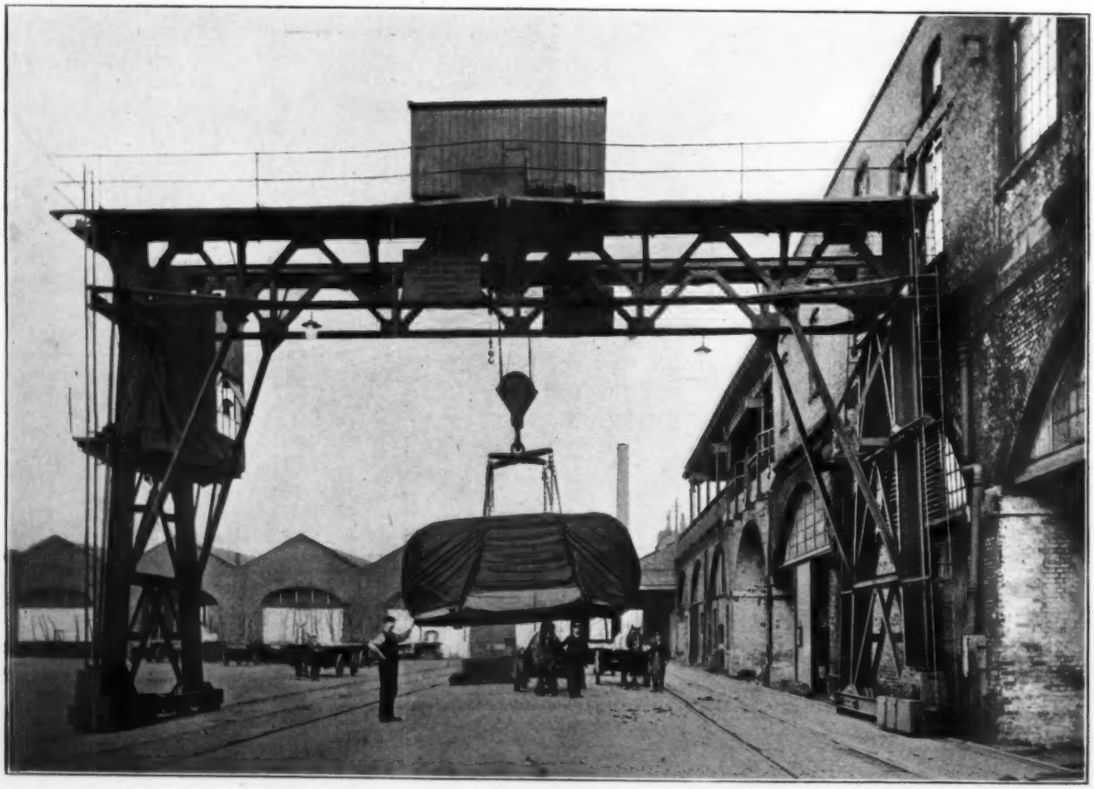

FIG. 14. 20-TON ELECTRIC GOLIATH CRANE IN GOODS YARD.

(*To face page* 171.)

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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With a Two-Page Plate of the RECONSTRUCTION OF THE OLDHAM-ROAD GOODS STATION, MANCHESTER; LANCASHIRE AND YORKSHIRE RAILWAY.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 23, at 7.30 p.m. Mr. C. D. G. Burdett, on "Random Notes on Structural Design." Friday, March 2, at 7.30 p.m. Mr. S. A. Roberts, on "Tool Store Management."

THE ROYAL SOCIETY OF ARTS.—Tuesday, February 27, at 4.30 p.m. Colonial Section.—"The Empire's Assets and how to use them," by Mr. Alfred Bigland, M.P. Mr. W. A. S. Hewins, M.P., will preside. Wednesday, February 28, at 4.30 p.m. "The War and our Supply of Drugs," by Mr. Francis Almond Hocking, B.Sc., Pharmaceutist to the London Hospital. Dr. Robert Hutchinson, M.D., F.R.C.P., will preside.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 2, at 5.30 p.m. A discourse will be delivered by Mr. Charles F. Cross, B.Sc., F.C.S., F.I.C. The subject is "Cellulose and Chemical Industry (1866-1916)" (Experimental). Afternoon lectures next week at 3 p.m. Tuesday, February 27. Professor W. E. Dalby, M.A., B.Sc., F.R.S., Professor of Engineering, Imperial College of Science and Technology, London, on "The Strength and Structure of Metals" (Lecture I). Thursday, March 1. Professor Edward S. Prior, A.R.A., M.A., F.S.A., Slade Professor of Fine Art, Cambridge, on "Memorial Art To-Day" (Lecture II). Saturday, March 3. Mr. Daniel Jones, M.A., Reader in Phonetics in the University of London, on "The Pronunciation of English at the Time of Shakespeare" (Lecture II).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, FEBRUARY 23, 1917.

IMPERIAL PREFERENCE IN TRADE.

THE significance and importance of the report on imperial preference made to the Government by the Committee on Commercial and Industrial Policy, presided over by Lord Balfour of Burleigh, cannot be overestimated. Prior to the war there was a sharp cleavage of opinion on the subject of tariff reform, many, including Lord Balfour himself, being anxious as to the effect any change in increased Customs duties might have in restraint of trade, apart altogether from the effect on international relationship. The war, however, in this, as in many other matters of imperial import, has resulted in a clearer perception of the means whereby the British Empire can be made safe. A long period free from great conflict had conduced to a complacent acceptance of conditions without regard to their effect in the event of a great European conflict. So long as we were prospering in a moderate degree we were not disposed to inquire too deeply into the ulterior objects of possible competitors in the absorption of our possible sources of supply, in the subtle yet effective capturing of international trade, and even in the slow paralysing of vital industries by reason of the monopoly in the supply of the necessary raw materials. Through adversity we have gained the light, and now see more clearly that ideas which seemed distasteful in the abstract must now be accepted in principle and acted upon if the Empire is to be maintained in a state of defence, either in war or peaceful trading.

Mr. Asquith's Government last summer appointed Lord Balfour's Committee to consider the commercial and industrial policy to be adopted after the war, with special reference to the conclusions reached at the economic conference of the Allies at Paris. The terms of reference were advisedly broad, and the composition of the Committee included men of great knowledge and wide experience in industry, commerce and economics. Moreover, in their public utterances, the members had previously foreshadowed most diverse attitudes of mind regarding the problem of tariff reform. They were asked to consider what industries are essential to the future safety of the nation, and what steps should be taken to maintain and establish them; what steps should be taken to recover home and foreign trade lost during the war and to secure new markets; to what extent and by what means the resources of the Empire should and can be developed, and to what extent and by what means the sources of supply within the Empire can be prevented from falling under foreign control. The report now issued does not cover the whole field. It recommends by resolution certain definite and workable propositions in favour of preferential tariffs for the benefit of the Empire, in order to stimulate the production of foodstuffs, raw materials, and manufactured articles within the Empire, wherever the expansion of production is possible and economically desirable for the safety and welfare of the Empire as a whole. There follows as a natural corollary the recommendation to impose Customs duties upon imports into the United Kingdom on a very much wider scale than hitherto, in order that such preference shall be given to the overseas Dominions and other units of the Empire, and further, to constitute a basis for commercial treaties, giving preferential treatment to allied and neutral Powers. The Committee, when they have examined the reports now being prepared by Special Committees appointed by the Board of Trade to consider the special conditions applicable to the sectional trades, will later issue a further and more detailed report, dealing with the nature of the industries to be encouraged and the extent of support to be given.

Lord Balfour's Committee, in a covering letter, make it quite clear that the fiscal reform issue has been completely changed as a result of war experience, and that the primary object is not so much protection *per se*, to which objection was formerly taken, but rather the delivery of the Empire from those influences from which we have so seriously suffered during the war, by reason of the crippling of some of our industries, consequent upon the insidious work of the German empire in paralysing some trades at their source of strength. The Dominions have never sought for preference merely on the grounds of commercial gain. At the Colonial conference of 1902 the Prime Ministers of the self-governing Colonies unanimously urged the expediency of our granting them preferential treatment, and some time later showed their earnestness towards uniting the Empire and consolidating its resources by granting us a certain measure of preferential treatment for our imports into several of the Dominions. Their attitude was very well expressed by Mr. Deacon, who at the Conference in 1907 stated: "We are not pleading for something which is to involve sacrifices, but for a co-operation which is to be mutually beneficial." In the progress of the war nothing has been so impressive of our imperial concord as the unanimity with which our fellow imperialists from over the seas have rallied to the Empire forces, the courage with which they have fought in all parts of the battle line, and the heroism with which so many of them have laid down their lives. There can consequently be no surprise that men who formerly objected in the abstract to tariff reform, because it might tend to the restraint of some trades, can now realise, to quote the letter by the Committee, that "any abstract opinions we may hold should not, under the circumstances in which we are placed, and with the experience gained during the war, stand in the way of any measures which are seen to be important, having regard to the general interests of the Empire." The recommendation, therefore, for imperial preference is unanimous on the part of the members of the Committee, having wide interests and formerly expressing widely varying opinions. When the next Imperial Conference is held—a few weeks hence—in order that the full views of the Empire shall be expressed regarding the future conduct of the war, as well as the establishment of permanent safety and Empire solidarity, our visitors from over the seas will have before them a definite agreement with their aspiration to extend those principles and develop those ideas which they have proposed, with every confidence, since the beginning of the century.

That justice to our Allies must be done is clearly accepted in the terms of the resolutions by Lord Balfour's Committee. These proclaim the desirability of establishing a wider range of British Customs duties, which while they would be remitted or reduced on the natural products and manufactures of the Empire, would form the basis of commercial treaties with allied and neutral nations. The ideal result would be to achieve free trade within the Empire, as far as possible under the special or national circumstances of our Dominions. The duties imposed would be against foreign countries, with special preferential treatment for Allies and

friendly neutrals. This is only in accordance with the resolutions come to at the Conference of the Allies in Paris last year. Until Customs duties are imposed on a much wider scale than hitherto it is impossible to carry the Paris Conference resolutions into effect. The extent of tariff duties, as well as their incidence, must be arranged to meet these twofold objects, always with the proviso that the industries essential to the future safety of the nation should be conserved by every possible means, and that the resources of the Empire should be developed, in order, as far as possible, to make the Empire independent of all foreign sources for the supplies essential to safety and prosperity. This necessarily involves such imposition of tariffs as shall preclude any possibility of any foreign country absorbing our natural sources of supply of raw material, or of monopolising the manufacture of the essentials to great industries. Under the first category we have only to mention the case of those rare metals without which munitions of war are impossible, *i.e.*, wolfram, molybdenite, tantalum, and niobite, in regard to the value of which to the Empire's resources little interest was taken prior to the war. One of the results was, for instance, that from British Malaya Germany exported in 1913 to the value of 115,536*l.* of wolfram ore, as against 1,000*l.* by the United Kingdom, while from Australia the exports of the same material were about 57,000*l.* worth to Germany, and about 13,000*l.* to the United Kingdom. Again, of scheelite Germany took 73 per cent. of Australia's exports and Britain only 7 per cent. Other cases might similarly be given. As regards the crippling of an industry, there is the most convincing case of the dependence of our enormous textile industry upon aniline dyes, in the manufacture of which Germany had, by subtlety and industry, gained a monopoly, due in part to lack of Government encouragement and in part to the ineptitude—almost lassitude—of Great Britain in this branch of the chemical industry. The practice of dumping, so sedulously pursued by Germany, has also had great effect on many of our staple industries, and particularly in metals. The effect was a restriction in the expansion of those industries. Fortunately, during the war there has, of necessity, been an enormous development in our metal-producing plant, and its influence upon peaceful trade must be consolidated by now giving effect to the recommendations of Lord Balfour's Committee.

In fixing the details of this far-reaching tariff reform great care will require to be exercised. But in subsequent reports Lord Balfour's Committee will have the advantage of the advice of experts dealing independently with the most important industries. Shafting, which is a completed production of the steel manufacturer, is in large measure the raw material of the engineer. So with leather, which is a complete manufacture, but is the raw material for several industries. Textiles come under the same category. But it cannot be "beyond the wit of man" to arrange the amount of the Customs duties with due regard to the state of manufacture of the articles taxed, to the importance of the incoming goods to the industries of the country and to their source of origin. In the same way there need be no fear of manufacturers' export goods being crippled in competition in neutral markets. It would be quite feasible, for instance, to grant a rebate to the shipbuilder building ships for a foreign nation in the case of the units of the ship which had to be imported, and for which import duties had been paid. The main aim is to increase our supplies from the Dominions over the seas. We are glad to recognise that more attention is being devoted to a study of such imperial questions, and we welcome the series of 1*s.* imperial handbooks which are to be published, under the auspices of the Duke of Newcastle's International Information Committee, by the *Athenæum*, and the first of which, dealing with the resources of the Empire, and just issued, shows the possibilities which may accrue from the adoption of the recommendation of Lord Balfour's Committee. In the case of cotton, Lancashire requires on an average 2,000,000,000 lb. weight of raw material per annum, of which 1,500,000,000 come from the United States, 400,000,000 from Egypt, and 100,000,000 from British India and other possessions. But there is very properly a scheme for extending the sources of imperial supply which should be fully encouraged. In the case of wool, almost all our supply is from British sources. Raw silk or flax comes in small part only from India and Hong Kong, the remainder being from China, Japan, France, Italy and Turkey; but here also there is no reason why there should not be development within the Empire. Of wood and timber only 16 per cent. of our imports come from British possessions. In the case of oil there are also potentialities for imperial supply, but at present the great preponderance is from the United States, Mexico, Russia and Rumania. Of iron ore 60 per cent. comes from Spain, Newfoundland alone, among our colonial sources, sending us any appreciable quantity. Of copper we produce only 5 per cent. of our requirements, Chile, Mexico, South America and Spain providing the remainder. There are possibilities for an expanded supply from Australia. Nickel is supplied from Canada and Australia, but Germany had controlled the supply from the former Dominion. Of zinc and spelter Germany in 1913 supplied us with 54,686 tons and Belgium with 57,207 tons, out of a total importation of 137,268 tons; in Australia German firms had complete control of the spelter markets of the world. It will therefore be recognised that there are great possibilities of imperial development, and at the same time of friendly trade association on an extended scale with the allied countries, so that the unanimous recommendations of Lord Balfour's Committee will be very widely approved.

LIQUID FUEL AND ITS COMBUSTION.

So much attention is claimed by internal combustion engines that the problems of oil fuels for steam-raising seem almost to be neglected, although the Navy could not do without that fuel. The British Admiralty specification for petroleum and shale oils demands a flash-point (close test) not lower than 175 deg. F. (200 deg. for shale oils of lower viscosity); the water percentage must not exceed 0.5, the acidity not exceed 0.05 (calculated as oleic acid), and the sulphur not exceed 3 per cent.; this last allowance is high, and is sometimes held responsible for cases of rapid destruction of boiler tubes. The United States Bureau of Mines stipulates 140 deg. F., water 2, and sulphur 1 per cent., and a calorific power of 18,450 British thermal units (18,000 minimum). The Admiralty does not specify the calorific power, but the various petroleums, though chemically very different, do not differ much in ultimate composition, and practically all satisfy the calorific power specification.

This country can draw its supply of fuel oils from two sources, from the shale oils and from the tar oils and crude tar. The shale oils, Professor J. S. Brame, of the Royal Naval College, Greenwich, pointed out in a paper of the above title read before the Institution of Petroleum Technologists last Tuesday, are an almost ideal fuel. The tar oils are inferior to petroleum because they contain a sufficient amount (15 per cent., about) of combined oxygen to lower the calorific value to 15,850 British thermal units on average; a crude tar of density 0.989 and flash-point 190 deg. gave 16,300 British thermal units, *e.g.*, and after washing with soda 17,490. At present tar is, of course, too valuable to be used as fuel; in normal times the production will probably satisfy the demand, though the tarring of roads will claim large quantities of dehydrated and debenzolised tar. If low-temperature carbonisation were really adopted—it is so much talked about that one fancies it must be practised—millions of gallons of tar might be gained, and, as Professor Brame remarked, a large portion of this would be available as liquid fuel. Reviewing the methods of combustion, first by gasification, and then by atomisation with the aid of steam or air, or simply of pump pressure, he showed that many of the different atomisers had their advantages. Against the use of steam were the facts that one boiler had to be got under way with other fuel, or a small auxiliary boiler be used, and that the consumption of steam for the atomisers represented 4.5 per cent. of the total steam generated. The United States Liquid Fuel Board had found a consumption of 0.6 lb. of steam (at 274 lb. per sq. in.) per pound of oil; others reckoned on a steam consumption of 0.8 and 0.85 lb. In 19 trials of air atomisers that Board found that the air consumption ranged from 5.7 to 70 cub. ft. per pound of oil, the average being 26.5 cub. ft.; the steam wanted for operating the blowers averaged 0.565 lb. per pound of oil. Under the special conditions of naval use pressure atomisers were without rival, but a sufficient number of atomisers should always be installed to reduce the blowpipe effects.

Touching upon the question of removing the water in the oil by the aid of heated settling tanks, Professor Brame could refer to a quite recent case in which settling tanks would have proved a saving. The heating of the oil promoted the separation and settling of the water, and was, moreover, essential for pressure-spraying. The following experiments made with Koerting atomisers illustrated the advantages of moderate oil temperatures (column A, deg. F.) and high oil pressures (B, in lb.); C marked the oil consumption per burner per hour, and D the water evaporated per lb. of oil:—

A.	B.	C.	D.
212	60	280	14.90
162	105	410	14.06
110	140	610	16.1

As regards viscosity, Mr. Arnold Phillip, Admiralty chemist at Portsmouth, had found that the viscosity of thick oils could be greatly reduced by adding 8 per cent. of naphthalene to the oil.

Suitable furnace arrangements are, of course, as essential for oil fuel combustion as efficient atomisers, and there has been too much mere adaptation of the oil furnace to the coal furnace. Professor Brame laid great stress on these points. The coal on the grate obstructs the air flow; in oil furnaces there is danger of excess of air. On the other hand, Professor Brame exhibited diagrams of short furnaces sending hot gases up the chimney, which had been improved by adding an oil-combustion chamber in front. Comparatively ample combustion space had to be provided for the oil. Assuming that the pound of oil required 180 cub. ft. of air, coal 150 cub. ft., that the oil evaporated 14.5 lb. of water per hour, the coal 9.5 lb., and that the ton of oil gave 20,000, and the ton of coal 12,000 cub. ft. of gas, disregarding in both cases about 2,000 cub. ft. of tarry vapours, then 1,000 lb. of oil would require 180,000 cub. ft. of air and 1,525 lb. of coal 229,000 cub. ft. for evaporating 14,500 lb. of water; but of the latter figure 150,000 cub. ft. would be required for the solid fuel on the grate, and only 79,000 cub. ft. for the gases distilled out of the coal. This distillation went on progressively over a large grate area, and small combustion space was sufficient; but the atomised oil was injected at high velocity, and the spreading flame required ample combustion space to prevent incomplete combustion. The matter became clearer perhaps if the air were considered to be the combustible; then with oil 180,000 cub. ft. of air had to be burnt, and with coal 79,000 cub. ft. Baffle plates and brick arches were often considered indispensable for facilitating the oil combustion. Professor Brame sided with the Fuel Board, which had expressed little confidence in the endurance of arches and contented itself with a firebrick lining for part of the furnace and a simple vertical firebrick wall; he himself advocated a split fire-bridge or hollow arch and a hollow firebrick floor, especially for water-tube boilers.

With respect to the extraordinary impossible evaporation figures (46 lb. of water per pound of oil) sometimes claimed for steam injection and ascribed to the heat generated by the combustion of hydrogen set free from the steam, he rightly asked where the heat required to break up the steam came from. The interaction between steam and hot carbon (the water-gas reaction) was endothermic and could only lower the flame temperature, and there was no proof for any direct action of the steam on oil, supposed to yield hydrogen and carbon monoxide; from the combustion point of view the balance was against steam. That view will probably meet with general acceptance, as well as Professor Brame's concluding quotation from Mr. Beeby Thompson that the burning of oil in boilers can only be regarded as wanton waste—in general. Professor Brame would not restrict warships and

big liners as to the choice of fuel. He also referred to oil-fired boilers in electric-power stations to help over the peak load, however, and as oil furnaces for metallurgical operations have become almost indispensable, it will be difficult to draw a line.

THE REORGANISATION OF THE L.C.C. TRAMWAYS ADMINISTRATION.

IT has long been a tradition with our public services, whether national or municipal, to reduce to a minimum the number of officials privileged to exercise initiative. The natural result has been an inordinate increase in the clerical and statistical work of every department, a dozen clerks being employed to transmit to headquarters for settlement matters which should have been dealt with on the spot by the official most directly concerned. Nor have matters stopped at compelling the technical heads of important services to deal with an avalanche of trivial details, but the initiative of these has, in its turn, been stringently restricted. The late Mr. W. B. Bryan, for example, stated that as chief engineer of the Metropolitan Water Board he could not, whatever the emergency, authorise on his own responsibility the expenditure of any sum in excess of 5*l*. In view of this evil tradition it is gratifying to note that the London County Council are now proposing very important changes in the technical direction of their tramways system. Hitherto the usual plan in municipal services has been to reduce to a minimum the amount spent on the "brains" of such undertakings, whilst a sympathetic ear was always open to demands for further expenditure on the lower grades of the services. These are engaged almost exclusively in routine duties, in which, as our war experiences have shown, previously untrained labour can readily become efficient in the course of a few weeks' tuition. Possibly the discovery of the facility with which most of the lower grades of labour can be replaced at need may have had its influence in emphasising, in the eyes of the public, the importance of the services of the higher staff, which could in an emergency be much less readily extemporised. Indeed, Mr. Carnegie is reported to have stated some years ago that when engaged in steel-making he could better have afforded the destruction of the whole of his works than the loss of his staff. It is as gratifying as unexpected to note in a popularly-elected body some realisation of the truth of this precept, and it will be interesting to observe how far the new policy of the County Council will be followed by other public authorities.

The new arrangements will, to a large extent, reverse the procedure followed in 1910 when, on the resignation of the electrical engineer, the post was not filled up, but the work transferred to an assistant at half the electrical engineer's salary. A somewhat similar saving (?) was at the same time effected in the traffic department. Economies of this kind are seldom satisfactory, and the Highways Committee state definitely that there is room for considerable improvement in the status of the technical and professional officers, whose salaries they now propose to augment by amounts aggregating some 5,600*l*. per annum. They note that it is impossible, in view of the various services competing with the tramways, to retain the abler officers at the existing rates of pay. They further observe that a large proportion of the work of these officers has in the past been of a routine or executive nature, questions having to be referred to heads of departments which they propose in the future subordinate officers shall have authority to settle for themselves. They also state that much of the time of these technical officials has been taken up in preparing unnecessary reports, and express the hope that when normal conditions are resumed members of the Council will refrain from demanding reports on matters not of general interest. An important innovation proposed is that heads of departments shall attend sittings of the committee and sub-committees when matters directly concerning their work are under discussion. Much time may thus be saved. Subordinate officers are further to be given power to engage new hands directly. Hitherto a large percentage of all new men taken on have had to report at the head offices before being engaged, and many men, it is stated, refused to make a long journey to a distant office on the off-chance of being successful in their quest for work. Under the new arrangement the tramways department will be subdivided into five branches, all under control of the chief officer. These branches will be, respectively, the traffic branch, the electrical branch, the rolling-stock branch, the permanent-way branch, and the general branch. The head of each branch will be paid a reasonable salary, such as may perhaps serve to retain in the service really capable men. An attempt is also to be made to relieve these heads of branches of the inordinate amount of routine and executive work which has been the common lot of similar officials in the past.

THE MECHANISM OF CHEMICAL CHANGE.

IN spite of all modern sensational discoveries one may say that science has arrived at a stage when further progress cannot but be slow. Theory is, on all its paths, approaching fundamental problems. As regards the mechanism of chemical reactions, chemistry may appear to stand very much where it stood a century ago, when particular reactions were ascribed to particular affinities. The course of experimental lectures which Professor F. G. Donnan, F.R.S., of University College, London, delivered at the Royal Institution on the Thursdays of the past three weeks may at first have conveyed that impression. He had to point out that no fundamental theory of reaction could be advanced as long as the structure of the atom was not understood. But the chief lesson of his lectures marked progress in a sense in which it was not understood a century ago: We live at the bottom of a low-temperature atmosphere in the high-temperature light of the sun; the light builds up life, food and fuel; our civilisation will become more like that of the plant; the roaring furnaces and high-temperature reactions are giving way to low-temperature catalytic and radiation reactions.

Lavoisier's work on oxygen and high-temperature combustion, Professor Donnan remarked in his introduction, was less suggestive as to the mechanism of combustion than the speculations of the phlogiston school had been. Schönbein's discovery of the slow oxidation of phosphorus, kept under water, by a current of air, had been as great a curiosity almost as the discovery of radioactivity in our days. That slow oxidation yielded ozone, an active form of oxygen, and it was accompanied by a faint luminescence. When ether was dropped on an iron plate, previously heated, a column of luminous vapour, oxidised ether, could momentarily be seen; the silent electric discharge generated ozone, and radiations, it was now recognised, generally played an important part in chemical reactions. To account for the activity of ozone, Schönbein suggested that the oxygen molecule split up into electro-negative ozone, uniting with the phosphorus, and electro-positive antozone, forming hydrogen peroxide with the water. The essential point was that ozone contained oxygen at a higher chemical potential, and the autoxidation theory—an unfortunate name—of Traube and Engler assumed that an element R in oxidising first formed a peroxide or holoxide RO_2, which then split up into the oxide RO + O, the O in the RO being at a lower and the free oxygen at a higher potential. The speeding-up of the oxygen might also be effected by a reducing agent. When air was bubbled through the green nickelous hydrate $Ni(OH)_2$, suspended in water, nothing happened; but when a little sulphur dioxide, SO_2, was added to the hydrate, the latter turned out the black $Ni(OH)_3$; the SO_2, it was assumed, took up oxygen, turning into $SO_2\langle{}^{O}_{O}$ which broke up into SO_3 + O. The isolation of these intermediate compounds was not always possible, and their existence in fact sometimes doubtful. The action of oxygen on the gas PH_3 increased when the gas pressure was lowered. Theoretical considerations had been based on similar reactions by Van't Hoff and Bodenstein; but such arguments appeared dangerous, for physical laws broke down when we had to deal with a few individual molecules instead of with statistical averages. The corrosion of metals was mostly a low-temperature autoxidation, though frequently other factors intervened. In aluminium, *e.g.*, the corrosion did not as a rule go beyond the formation of an oxide film; that film prevented the deposition of copper on the aluminium when it was dipped into copper sulphate solution; when, however, a little sodium chloride was added to the sulphate, the chlorine ions penetrated through the oxide film, and copper was deposited.

With these latter reactions Professor Donnan had already passed over to catalytic effects. When it was observed about 1800 that a little sulphuric acid would turn large masses of starch into sugar, the acid apparently remaining intact, the then prevalent theory of chemical affinity failed. Mutual decompositions like AB + CD = AC + BD had been explained by the assumption that the sum of the affinities was greater on the right side of the equation than on the left. But in this case the affinity of the acid did not seem to enter at all. Then Humphrey Davy noticed that the platinum of his safety lamp continued to glow after extinction of the flame in an air rich in fire-damp; Edmund Davy, an assistant at the Royal Institution, observed that many oxidations took place at ordinary temperature in the presence of finely divided platinum; Döbereiner presented one of his lamps [a jet of hydrogen catches fire when impinging upon spongy platinum] to the Institution. Berzelius introduced the term catalysis to account for these new reactions, which, though not impossible otherwise, were accelerated [or retarded] by the mere presence of small quantities of other substances. Mitscherlich and Liebig preferred to speak of contact reactions and adsorptions. Faraday, observing that his electrolytic hydrogen and oxygen slowly recombined at the platinum electrodes, thought that the gases were condensed together on the surface of the platinum and, losing some of their elasticity, became more reactive chemically. There was something in these various suggestions; but one of the essential factors, the action of the catalyst as carrier of the oxygen, had already been recognised by Clément and Desormes in 1806 in connection with the lead chamber process [which had been developed since 1740, though for many decades without towers]. The nitrous vapours from sulphuric acid and saltpetre, they pointed out, took up the oxygen from the air in a suitable form and transferred it to the SO_2 (from burning sulphur), oxidising the latter rapidly to SO_3. The contact process of making sulphuric acid with the aid of platinum, now so important, had been foreshadowed by Döbereiner. Professor Donnan demonstrated the Ostwald process, oxidation of ammonia to nitric acid, which was now practised on a large scale: Ammonia was heated in a small flask, and air bubbled through it; the vapours of ammonia and the air passed over hot particles of platinum in the higher portion of the flask; brown fumes of NO_2 and white fumes of ammonium nitrite made their appearance almost immediately. The oxidation of ammonia was also demonstrated in another interesting way. A hot platinum spiral was dipped into a flask containing liquid ammonia through which oxygen was being bubbled; the platinum brightened up, a slight explosion was heard, the platinum turned dark, slowly brightened up again, a second explosion followed, and so the rhythmic oxidation proceeded. Water, Professor Donnan continued, was one of the most noteworthy catalysts; many gases did not appear to react upon one another when perfectly dry, but did so in the presence of traces of water vapour (V. Harcourt, H. B. Dixon, Brereton Baker). Inorganic catalysis had been particularly studied by Ostwald and Bredig, organic by Sabatier and Sendérens. The isolation of the intermediate compounds was often as difficult in catalysis as in the cases of autoxidation, and the existence of these compounds as doubtful; the chemist could not trace the rates of the various reactions, and the phenomena of catalysis remained mysterious. Novel lines of research and experiment, however, promised to clear up the mechanism of chemical change.

The kinetic theory of gases failed to explain chemical activity. When gaseous particles were compressed and brought closer together, the number

of collisions should increase, and the breaking-up (dissociation) of compounds should hence be accelerated by an increase in the gas pressure, one would expect. But this was not so, and a rise of temperature of 10 deg. increased the velocity of reaction by more than 200 per cent. in general, whilst the number of average collisions was only increased by 2 per cent. The increase of the kinetic energy of the molecules as a whole would not account for more than a very small fraction of the effect observed, and the effect of temperature must therefore be connected with the internal (not the kinetic) energy of the molecule. Distinguishing active and inactive molecules, Arrhenius had suggested that rise of temperature displaced the equilibrium towards the active side: $d \log k/d T = A/R T^2$, where k was the velocity of reaction, T the absolute temperature, R the gas constant, and A a constant. From considerations of statistical mechanics, Marcelin and F. O. Rice had replaced the A in this empirical formula by E, the critical increment necessary to the energy of a molecule to render it active. If not from other sources, the energy might come from waves of light. Grotthuess had already taught that light had an important chemical function, not any kind of light, however, but those rays which one of the substances was able to absorb. Luther and F. Krüger had built further on this basis, and from this standpoint one might broadly distinguish between photocatalytic reaction and photo-end-energic reaction—the latter term being tentatively suggested by the lecturer to cover all radiations. That illumination by the electric arc or the mercury arc induced many reactions between gases and liquids which remained indifferent until illuminated was demonstrated in various ways; mixtures of chlorine and benzene vapours, *e.g.*, at once condensed to a mist of CCl_6 when illuminated. Einstein, Professor Donnan proceeded, had, in 1912, applied Planck's quantum theory to photo-chemical reactions, which, Einstein argued, took place when each molecule of a (photo-sensitive) substance absorbed one energy quantum $h\nu$ (h the universal constant, ν the requisite frequency of the vibrations). This suggestion had been developed by W. McC. Lewis (Liverpool), who found the main source of chemical change, and of the increase in the rate of change, in infra-red radiations, which would always be present to a certain extent. The effect of the catalyst would then consist, not in the production of intermediate compounds, nor in the opening-up or loosening of the field of molecular force (E. C. C. Baly)—a thing we could not measure—but in the production of a higher radiation density. The E of Marcelin and Rice, the excess of the energy of a molecule above the average energy, then became $E = N h\nu$ (where N was Avogadro's number, the number of molecules per gramme-molecule), and on this basis photo-chemistry might generally be called radiation-chemistry.

We need not say that we have not been able to notice more than a very few of the experiments, demonstrations of historical original experiments as well as novel demonstrations.

NOTES.

The Fuel Problem.

It will be remembered that a very important discussion on ways and means of economising our fuel supplies took place last year at the Newcastle meeting of the British Association. There was a general agreement as to the great advantage to the nation of reforms in our present methods of using, or rather of wasting, coal; but considerable divergences of opinion were manifested as to the most promising line of procedure in practice. Many of the chemists appeared to regard coal almost exclusively as the source of the raw materials they require for their manufactures. Engineers were more concerned in the mineral as the main source of the power used in driving our factories, whilst the colliery men frankly admitted that to them coal was simply a commodity for sale. Nevertheless, some progress was made towards a reconciliation of these separate view-points and a strong committee formed further to consider the matter in the hope that it would be possible to bring forward at the next meeting of the Association a record of some really practical progress towards the end desired. It is now announced that the Privy Council Committee of Scientific and Industrial Research has appointed a Board of Fuel Research under the direction of Sir George Beilby, F.R.S., with whom will be associated Sir Charles Parsons, F.R.S., Sir Richard Redmayne (Chief Inspector of Mines) and Mr. Richard Threlfall, F.R.S., whilst the services of Professor W. A. Bone have been secured as consultant. This new Board is to co-ordinate the work of Lord Haldane's Sub-Committee on Coal Conservation and the British Association Committee, and it is hoped that assistance will also be received from the Admiralty and Ministry of Munitions. The new Board will, with the assistance of the two committees above-named, investigate the nature, preparation and utilisation of fuel of all kinds, both in the laboratory and, where necessary, on an industrial scale. The funds required will be provided from the national exchequer. It is estimated that better methods of utilising fuel would result in an annual saving of 50,000,000 tons of coal.

The Elastic Limit.

We have long held the view that only under special conditions and kinds of stress does the elastic limit form a proper basis for the proportioning of machine parts or the elements of structures. To this general rule the main exception is provided by the case of alternating stresses. Here the trend of experience gives support to the view that safety is to be sought by keeping the range of stress within the elastic range of the material. In some other cases it is also advisable to use the elastic limit as the basis for proportioning dimensions, since even though an excessive stress might not actually endanger the safety of the structure, the risk of a permanent set may be highly undesirable. As instancing how little the safety of structures, strained in one direction only, is dependent on the elastic limit, the bombs used by Professor Bridgman in his experiments on the behaviour of materials under extremely high pressures may be referred to. The process of producing them is described by Dr. J. Johnston in a paper published in the Journal of the Franklin Institute. A block of steel, after appropriate heat-treatment, is bored with a hole 1 mm. less in diameter than the intended final dimension. This is then filled with kerosene oil and subjected to a pressure of 20,000 atmospheres or more. This causes a bellying out of the hole, which is then reamed to its final diameter. Under this treatment the metal is so strengthened and stiffened that the bomb is capable of carrying repeated applications of pressures of 10,000 atmospheres or more. The leak-proof piston used with these bombs consists of a hardened steel plug finished a nice fit to the hole. This piston is packed by a series of washers, successively of rubber, copper and of soft steel, which are followed by a hardened steel collar which takes the thrust of the ram by which the pressure is applied. The methods followed by Professor Bridgman have, we think, a bearing upon turbine engineering. With the rapid increase in size and speeds the stresses on the wheels at the exhaust end of the turbine have risen greatly, and further progress may be checked if designers persist in estimating their factors of safety on the basis of the elastic limit. The stresses to which such wheels are subjected are nearly as steady as hydraulic pressures, and actual experience has shown that no permanent injury results even if the metal be strained considerably beyond its elastic limit. For example, at the Birmingham meeting of the British Association in 1913 Mr. Gerald Stoney recalled an instance in which a wheel intended to be run at 5,000 r.p.m. was by error tested at a speed of 8,000 r.p.m. The consequence was the bore stretched $\frac{1}{4}$ in. No permanent injury resulted, however. The wheel was rebored and passed into service, where it proved quite satisfactory. An overstrained material requires some little time to recover itself, but as this was allowed in the above instance the wheel was probably stronger than before.

The Steering of Aeroplanes.

In a paper recently read before the Society of Automobile Engineers, New York, Mr. E. A. Sperry discusses the difficulty of determining the true course, relatively to the earth, of an aeroplane or airship. The trouble arises from the fact that the speed of the air currents met with is often comparable with that of the craft itself. The machine drifts with the air, and if the latter is moving at, say, 15 miles an hour east, then, to maintain a true northerly path, the course set on the compass should be about 14 deg. west of north if the speed of the machine be, say, 60 miles per hour. The difficulty that arises in practice is that the aviator knows little *a priori* as to the direction and strength of the currents he may experience, and Mr. Sterry's paper is, in the main, devoted to a description of various instruments he has devised for enabling the airman to determine his true course. By means of his anemometer the pilot easily ascertains his speed through the air. If he can at the same time find his speed relatively to the earth, the true course can be determined by combining the two vectors. If a point on the earth be observed from the moving plane through a fixed telescope, the object will appear to cross the field of view, and will finally disappear. If, however, a suitable angular velocity be given to the telescope, the mark can be kept in the centre of the field. The angular velocity which it is necessary to give to the telescope is, of course, proportional to the speed of motion taken relatively to the point observed. This was the principle embodied in the first instrument devised by Mr. Sperry, and with it very satisfactory results were obtained. It was, however, found that, provided the true course relatively to the earth could be observed, the determination of the absolute speed was of secondary importance, and so a still simpler form of apparatus was devised. This consists essentially of a telescope provided with a cross-hair and capable of being rotated about the line of sight. A graduated arc was provided, on which the angle between the cross-hair and the axis of the aeroplane could be read off. If the earth be viewed through this, the objects visible appear to stream in parallel lines past the field of view. The telescope is then rotated until the cross-hair is parallel to these "stream-lines," and the angle between this cross-hair and the axis of the aeroplane is then equal to the angle between the true course and the apparent compass course. In a still further modification of the instrument the telescope and the lubber's line of the compass are geared together, so that if the observer keeps the telescope cross-hair parallel to the "stream-lines," the pilot can steer his nominal course by the compass without making any other allowance for drift. The necessary correction is, in fact, automatically provided for by the shifting of the lubber's line in agreement with the direction of the "stream-lines" as viewed in the telescope.

Insulating Oils and Dust.

Everybody understands that all dust has to be kept out of insulating oils. But it would hardly have been suspected that the process of cleaning the electrodes with cotton cloth may actually make matters worse, because it is liable to introduce dangerous dust in the shape of fine cotton fibres. Such is the case, according to the researches of Messrs. T. Hirobe, W. Ogawa and S. Kubo, of the Electrotechnical Laboratory of the Department of Communications, Tokyo (Report No. 25 of the 3rd Section of the Laboratory). The experiments—oil-insulation tests—were conducted in a glass cylinder of a capacity of 25 cub. in., in which the electrodes, brass balls, pointed wires, discs, &c., could be adjusted as to distance apart, and be easily removed for cleaning. When a potential difference is established between the electrodes in oil, any dust particles present tend to arrange themselves in a chain bridging over the electrode gap, and the fine cotton particles adhering to the electrodes produce sufficient dust, the experimenters found, to lower the breakdown kilovolts to one-third of their previous value. For these reasons they recommend the following mode of cleaning the electrodes in testing apparatus of their type. Immerse the cleaned electrodes in the oil, adjust the distance, and apply the highest possible potential for several minutes; the dust will concentrate in the gap. Wash the electrodes in the oil, take the oil out of the cup, and wash the vessel by stirring the oil in it. Charge the cup again, insert the electrodes, and repeat the

process; all with due caution, of course. It was observed that the discharge passed most readily between a point and a disc; contrary to expectation, however, the breakdown voltage between two discs was considerably lower than that between two spheres. Heating the oil is generally supposed to increase the dielectric strength. According to the experimenters this increase is more apparent than real, and probably due to the partial drying of any fibrous hygroscopic substances in the oil; according to F. W. Peck the dielectric strength ought to diminish on heating, and the Japanese workers are inclined to agree with that statement. The effect of moisture they consider slight as long as dust is absent. Oils dissolve very little water, only about 0.01 per cent.; with greater amounts of water oil forms emulsions, the particles agglomerating sooner or later. If water particles settle on the insulators, *e.g.*, on a high-tension coil, immersed in the oil, their effect may be disastrous. Dust particles, especially when fibrous, absorb the moisture; such fibres, it was found, readily bridged the electrode gap and caused breakdown. Thus the breakdown voltage of a good oil occurred at from 90 to 60 kv., with a gap of 150 mils, as the moisture increased; when the electrodes were "cleaned" by being rubbed with a dry cotton cloth a similar curve was obtained, but the breakdown occurred at from 35 to 15 kilovolts. In a high-tension transformer the dust is attracted towards the high-tension coil and accumulates on it; in such cases, it was noticed, a single fibre might suffice to cause disruptive discharge. Fortunately filtering through a proper press removes both moisture and dust, and it is recommended to keep the oil of high-tension transformers in constant circulation with the aid of filter presses.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new list of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway W.C.

THE INSTITUTION OF GAS ENGINEERS.—The annual meeting of the Institution is to take place in London on Tuesday, June 5. The president, Mr. Arthur E. Broadberry, will deliver his address, and the annual report of the council and reports of committees will be presented, but no papers will be submitted. On the following day, by invitation of the president, a visit to the works of the Tottenham District Light, Heat and Power Company will take place, to view the entirely new section of the works for the production and purification of 4,750,000 cub. ft. of gas per day, which is now approaching completion. Opportunity will also be given to inspect the company's electricity generating station at Wood Green.

THE PROGRESS OF THE MANCHESTER SHIP CANAL COMPANY.—The report of the directors for the year 1916 shows that in addition to the paying of 3½ per cent. on the Manchester Ship Canal Corporation stock, the preference shares get 4*s.* and the ordinary shares 2*s.* There was an increase of 74,416*l.* in the receipts from ship canal tolls, ship dues and miscellaneous receipts as compared with the previous year. The increase was almost entirely owing to the higher rates and charges put in force on November 1, 1915, and to a further advance operating from August 9, 1916. There was a decrease in the weight of sea-borne traffic on which ship canal tolls were paid of 575,787 tons, but the decrease chiefly arose in coal and other low-class traffic, which does not bear a high rate of toll. There is also included in the accounts an amount of 20,800*l.* for tolls and charges now paid or payable by Government Departments in respect of the year 1915, for which no credit was taken in that year's accounts because payment had not then been agreed to. In common with other ports, the port of Manchester suffered at times from a shortage of labour during the past year. Although this necessarily retarded the loading and discharge of vessels, still the port was kept practically free from congestion. The supply of labour was supplemented from time to time by contingents from the Transport Workers' Battalion. Increased war allowances have been paid to all the company's employees, and the cost of all materials, coal and other stores has been very heavy. Some of the work of repairs and renewals has again had to be postponed owing to the short supply of workmen, but adequate provision has been made for the work so postponed by the addition of 15,000*l.* to the reserve for contingencies and repairs. No portion of the reserve for contingencies and repairs which was made at December, 1915, has been spent. The total amount now reserved therefore stands at 30,000*l.* The toll-paying merchandise traffic for the year included 4,540,167 tons sea-borne and 318,582 tons of barge traffic, a total of 4,858,749 tons, against 5,434,045 in the previous year; but the receipts total 831,684*l.*, against 757,268*l.*, or double the total of 1904.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE 70th annual general meeting of the above Institution was held on Friday last, the 16th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the President, Dr. W. C. Unwin, F.R.S., occupying the chair.

ANNUAL REPORT OF THE COUNCIL.

The president, in presenting the annual report (which was taken as read) desired to refer to the large number of members who had died during the year, some twenty-three of these having been on active service. With the feeling of sadness occasioned he desired to associate some tribute to the honour achieved. The secretary had compiled a statement showing that there were 955 members of the Institution known to be engaged on active war service, of whom 540 were serving in capacities involving engineering knowledge and experience, such, for instance, as in the Royal Engineers, the Flying Corps, the Mechanical Transport Department, and the department of Machinery Inspection. About 180 others were in the Royal Field Artillery and the Army Service Corps, while 235 were engaged in the combatant ranks or in services of which the Institution had no definite knowledge. Dr. Unwin desired also to refer to the new war loan. He had requested the secretary to prepare a statement of the converted funds of the Institution, amounting to 16,620*l.*, and in addition the Institution had taken new war loan to the amount of 8,650*l.*, from which it would be seen that more than 25,000*l.* had been invested in the new war loan. Further, he would mention the fact that the total property of the Institution was 125,000*l.*, of which, if there were deducted the debentures, the temporary loan, and the fund which had been put aside for leasehold redemption, there remained, as assets which could be dealt with, 75,000*l.* At the moment, therefore, the Institution was certainly solvent.

Mr. Daniel Adamson suggested, for the consideration of the Finance Committee, that it would make the accounts more easily understood if the amount taken off every year for debentures and interest on leasehold property were shown in the revenue account rather than in the general balance-sheet. That course would not show such a large credit balance, which was called a surplus of revenue over expenditure. The amount was not correct as stated, because every year provision must be made for depreciation of the buildings held on lease.

The president remarked that the chairman of the Finance Committee would, no doubt, take the point raised into consideration. The annual report, of which a summary follows, was then adopted by the meeting.

ANNUAL REPORT OF THE COUNCIL.

On December 31, 1915, the total names on the roll were 6,319. In 1916 there were 311 additions and 383 deductions, of which 80 were by death, leaving 6,247 names of all classes on the roll.

His Majesty the King has conferred honours upon a number of the members, including a Baronetcy to Mr. Alfred F. Yarrow, and various appointments to the Companionship of the Order of the Bath, the Companionship of the Order of the Star of India, the Membership of the Royal Victorian Order, the Distinguished Service Order, the Military Cross, the Distinguished Service Cross, and the Albert Medal.

Twenty-three Members, Associate Members, and Graduates have been killed in action or died of wounds.

For the year ended December 31, 1916, the total revenue was 22,444*l.* 1*s.* 8*d.*, while the expenditure was 12,628*l.* 18*s.* 11*d.*, leaving a balance of revenue over expenditure of 9,815*l.* 2*s.* 9*d.* The total investments and other assets amount to 137,588*l.* 10*s.* 7*d.*, and, deducting therefrom the 34,025*l.* of debentures, a temporary loan of 6,000*l.*, and other liabilities, including the sum set aside for the leasehold redemption fund, the capital of the Institution amounts to 75,691*l.* 12*s.* 6*d.* The loan from Messrs. R. and R. H. Williamson has been reduced by another 1,000*l.*; and the total leasehold redemption fund has been increased to 19,083*l.* 8*s.* 11*d.*

The Thomas Hawksley Gold Medal for 1917 has been awarded to Mr. Daniel Adamson for his paper on "Spur-Gearing" (ENGINEERING, May 26 and June 2, 1916), and a premium of 10*l.* has been awarded to Second Lieutenant Robert W. Fenning, R.E. (T.), B.Sc., D.I.C., for his paper on "The Composition of the Exhaust from Liquid-Fuel Engines" (ENGINEERING, March 24 and April 7, 1916). The third award of the Starley Premium for the best paper published in the proceedings of 1914, 1915 and 1916 dealing with the development of road locomotion has been made to Mr. Robert E. Phillips, for his paper on "Variable-Speed Gears for Motor Road-Vehicles" (ENGINEERING, December 22 and 29, 1916). The fourth award will be made in February, 1920. The fifth award of the Water Arbitration Prize for the best paper published in the Proceedings of 1915 and 1916 dealing with certain specified subjects connected with water has been made to Mr. Walter Clemence, for his paper on "Theory and Practice in the Filtration of Water" (ENGINEERING, April 21, 28, May 5, 12, 1916).

A declaration of trust for the Bryan Donkin Fund has been prepared and sealed by the Institution. In clause 4 it sets forth that the income of the fund is to be devoted to grants in aid of original research in the science and practice of mechanical engineering. Mr. A. H. Barker, the recipient of a grant from the fund in February, has procured the apparatus for his research "to investigate a new method of determining the radiant temperature and air temperature in a room." The experiments are being conducted at University College, London, and the results will be embodied in a paper to be submitted to the Institution. The next award will be made in February, 1919.

The Institution examinations were held in October. Ten candidates passed the graduateship and eight the associate membership examination. On the results of the associate membership examination a prize of the value of 5*l.* was awarded to Mr. L. H. Thomas. The examination papers have been printed in pamphlet form. The next examinations will be held in October, 1917.

In January a conference of representatives of the five leading British engineering institutions was held at the Institution of Civil Engineers, to consider generally the Government scheme (July 23, 1915) for the organisation and development of scientific and industrial research, and the constitution of the advisory council. On the recommendation of the conference a petition was presented to H.M. Privy Council urging that the advisory council should be strengthened by the addition of some representatives of engineering industries. The petition having been declined, a further conference was held, at which a deputation was appointed to wait upon the Lord President of the Privy Council, Lord Crewe, and put forward some considerations as to the representation of engineering on the advisory council. The deputation was courteously received by the Lord President, who explained that the Privy Council did not at that time see their way to modify the constitution of the advisory council. [Subsequently it was officially announced that a charter had been granted to "The Imperial Trust for the Encouragement of Scientific and Industrial Research" (hereinafter referred to as the Government Department of Research).] Dr. Dugald Clerk, F.R.S., vice-president, was appointed to represent the Institution on the engineering committee of the Government Department of Research. Grants for one year have been made in aid of three researches carried out under the direction of the Institution, namely: Alloys, 200*l.*; Steam Nozzles, 300*l.*; and Hardness Tests, 100*l.*

In view of the work now being undertaken by the Government Department of Research, it has been considered desirable to take no further steps with regard to the proposal to form a general engineering research committee for the collection and co-ordination of engineering research.

Investigations into the alloys of aluminium with zinc and copper, under the direction of the Alloys Research Committee, have been continued at the National Physical Laboratory, but the publication of the eleventh report has been necessarily deferred until after the war. A grant of 200*l.* towards the prosecution of the research during the year 1916 was received from the Government Department of Research, and this sum, with a like amount from the Institution funds, has been handed over to the National Physical Laboratory. The committee has been enlarged by the appointment of Mr. John Dewrance, member of Council, as chairman, in place of the late Sir William White; Sir Gerard A. Muntz, Bart., member of Council; and Mr. William Mills, member.

The Hardness Tests Research Committee, under the chairmanship of Dr. W. Cawthorne Unwin, F.R.S., have carried on their investigations at the National Physical Laboratory with the object of measuring the resistance to wear on rolling or sliding surfaces and comparing it with indentation hardness. A testing-machine of a new type was designed by Dr. T. E. Stanton, F.R.S., and a number of specimens of steel were tested, including samples kindly supplied by Sir Robert Hadfield. The first report of the committee contained the results of experiments made by Dr. Stanton and Mr. R. G. Batson, associate member, together with appendices by Dr. Unwin, Sir Robert Hadfield, Dr. A. E. H. Tutton, and Professor T. Turner. The Government Department of Research granted a sum of 100*l.* for this work, and a grant of 10*l.* was made by the Council as part of the third award of the Bryan Donkin Fund. During the discussion of the report Sir Robert Hadfield expressed his desire to offer, through the Council, a prize for a new and accurate method of determining hardness of metals. The offer has been gratefully accepted.

The Steam Nozzles Research Committee have still under consideration the design of apparatus for conducting experiments relating to the action of steam passing through nozzles and steam turbines. Some experiments, using jets of compressed air in a cage designed by Mr. H. M. Martin, are referred to in the discussion of Captain T. B. Morley's paper, and some further trials with this cage have been made. As already stated, a grant of 300*l.* has been received from the Government Department of Research towards this work, and 10*l.* has been granted by the Council from the Bryan Donkin Fund. Captain H. Riall Sankey, C.B., R.E., member of Council, has continued to act as chairman; and Professor A. L. Mellanby, D.Sc., member, and Professor J. E. Petavel, F.R.S., member, have been appointed members of the committee.

Although the work of the Wire Ropes Research

Committee has been delayed on account of the war, further proposals for the testing-machine have been under consideration, and alternative modified designs are now in preparation.

Mr. Richard Williamson, member, has offered to the Government Department of Research 500*l.* towards a mechanical engineering research, to be conducted by the Institution. The best way of utilising this generous gift has received consideration, and the members have been invited to make suggestions for such a research.

With a view to assisting the maintenance and extension of British engineering trade after the war, the British Standards Committee have determined to translate their specifications into French, Spanish and Russian, to give metric equivalents of English measures and to issue the specifications at a much lower price than has hitherto been possible. Arrangements are being made to establish local committees in overseas and foreign countries, to obtain information and facilitate commercial transactions. The cost will be large, and an appeal was made to the Institution for a contribution to the fund which is being raised. The matter is considered so urgent that the work is already in hand. It was resolved to grant a sum of 500*l.* as a donation to the fund, the Council feeling that this work is of vital importance to British engineering firms.

The Council have been glad to give their support to a report on the education of the marine engineer, drawn up by a committee of the Liverpool Engineering Society. The efforts of this committee were directed to raising the standard of the marine engineer, both as regards theory and practice. The report is being submitted to the Board of Trade.

Advisory committees have been duly constituted by the Council to give advice and to make representations on matters affecting the members in India and South Africa respectively.

Benevolent Fund.

The Benevolent Fund has made grants to several members and dependents of members of the Institution. A donation from Mr. H. E. Jones of fifty guineas was much appreciated, being his fee for the delivery of the "Thomas Hawksley" lecture. Ninety life members have made donations of ten guineas and upward, and 149 ordinary members are annual subscribers of not less than half a guinea. It is much to be regretted that a large number of members of the Institution have not yet subscribed. It has been impracticable to vary the Institution memorandum of association with the object of enabling a grant to be made to the fund, as had been suggested.

Awards.

The next business of the meeting was the presentation of the awards for papers contributed, which had been made by the Council during the session. A brief reference has been made to these awards in the foregoing summary of the annual report.

Election of Officers.

The secretary stated that the ballot papers for the election of officers had been opened by a committee of the Council, and the following gentlemen had been found to be elected:—As President, Mr. Michael Longridge; as Vice-Presidents, Dr. Dugald Clerk, Sir Robert A. Hadfield, and Mr. Mark Robinson; as Members of Council, Sir A. Trevor Dawson, Mr. George Hughes, Mr. Robert Matthews, Mr. D. B. Morison, Sir Gerard A. Muntz, Bart., and Mr. William Reavell.

Induction of New President.

The president said that, having reached the end of his term of office, he had now to ask Mr. Michael Longridge to take the chair. Mr. Longridge had been a member of the Institution for some thirty-seven years, had long been a member of Council, and had been chairman of one of the most important committees. Mr. Longridge had earned the good-will of all with whom he had worked, and had seen the rise and development of the various associations for the examination of steam machinery started by the speaker's old chief in days when he (the speaker) was learning something about engineering. Mr. Longridge had become the greatest master in the country of the pathology of steam machinery, and the work done by the associations referred to had been of the greatest service, and mainly instrumental in bringing about the high speed of modern machinery. He was not inviting Mr. Longridge to a sinecure, the presidency of the Institution making considerable demands on time and judgment. Happily, however, the long experience of the Institution had established rules and precedents, which eased the difficulties a president was likely to meet. He wished the new president every success in the chair.

Mr. Michael Longridge then took the chair, remarking that he felt the keenest satisfaction in listening to the kind words which had accompanied his induction as president, and in observing the manner in which the members had associated themselves with Dr. Unwin's kind expressions. He could only hope that the farewell accorded to him on his retirement from the chair would be as cordial as his welcome to the office. He regretted that the ceremony had not taken place at the home of the Institution. It was to be hoped, however, that a return would be made to the Institution House before the speaker's term of office expired.

Vote of Thanks to Retiring President.

Dr. W. H. Maw, responding to the call of the president, said that as the senior past-president at the meeting it was his great privilege to ask the members to pass a hearty vote of thanks to the retiring president for his services to the Institution during the past two years. Dr. Unwin was pre-eminently a representative of the engineering profession, and there were few, if any, engineers who had not, at some time or other, been more or less directly indebted to him for information and for other aid. Dr. Unwin's work in connection with the development of technical education was well known, as were also its importance and far-reaching results, and the rising generation had all more or less benefited by his work in making technical training more practical. In the case of older engineers the indebtedness was scarcely less. The speaker recalled many hundreds of cases in which he had had to refer to Dr. Unwin's writings for information of which he had been badly in want, and he had never been disappointed in getting that information, which was always clearly and accurately stated. All must greatly regret that Dr. Unwin's period of office had not fallen in happier times. As the new president had said, the Institution had been excluded from its old home, although that loss had been greatly mitigated by the generous manner in which the Institution of Civil Engineers had received them and the aid they had rendered in many ways. Their Institution had also suffered from the depletion of the staff due to the war, and there had been difficulty in getting papers so readily as in ordinary times. Altogether, a great amount of extra work had been thrown upon the president and the staff of the Institution. Needless to say, those calls had been most thoroughly met, and only the Council, perhaps, could fully appreciate the great amount of extra work which had fallen upon the president during his term of office. The Institution had, moreover, been deprived of some of its social functions; there had been no public dinners, no conversaziones, and no summer meetings. The last-named loss was particularly great, as the summer meetings had been a striking feature of the work of the Institution ever since it was founded, affording as they did admirable opportunities for intercourse between members generally and the president and Council. It was therefore particularly to be regretted that Dr. Unwin had been deprived of the pleasure which, the speaker was sure, he would have derived had the summer meetings been held in the ordinary way. He hoped, however, that it would not be long before the summer meetings could be resumed, and that at future gatherings members might have the pleasure of Dr. Unwin's attendance throughout the excursions and various social functions. He had much pleasure in formally proposing that a most hearty vote of thanks be accorded to Dr. Unwin for his services to the Institution during his period of office.

Mr. W. H. Allen, who seconded the proposal, said that, as a member of Council, he had sat for two years with Dr. Unwin, and he could only regard the latter as a model president. So far as the speaker was aware, Dr. Unwin had not once missed a meeting, and had so familiarised himself with the work as to avoid delay, an important qualification in a chairman or president. Indeed, the amount of detail which the late president had at his fingers' ends was remarkable. In addition to his work as president, Dr. Unwin had endeared himself to members as a man. While, therefore, Dr. Unwin would be missed as president, the speaker trusted that the Institution would have the pleasure of seeing him often in his capacity of past-president. He had great pleasure in seconding the vote of thanks proposed by Dr. Maw.

The vote was then put to the meeting and passed with acclamation.

Dr. Unwin, in acknowledgment, thanked the members for the very kind way in which they had received the vote proposed; and Dr. Maw and Mr. Allen for the generous nature of their remarks about his work at the Institution. He had, when accepting the presidency, observed that the Institution was entering upon difficult times; in some respects, however, the times had proved even more difficult than could have been foreseen. The Institution had been deprived of the use of its building; the secretary had been obliged to carry on his work with a new and untrained staff. Yet he felt that there had been no obvious defect in the work. He hoped that ere long the times would be such that those pleasant and characteristic functions of the Institution which had had to be abandoned could be again undertaken. As a consequence of the war some of the members who were on active service became involved in various difficulties, and, when these difficulties had come to the knowledge of the Council, new by-laws had been adopted, which afforded, to some extent, the necessary relief. He would instance the case of candidates for examination who had been called up for active service; here modifications in the examination rules had been introduced to meet the particular difficulties.

Appointment of Auditors.

On the motion of Mr. Dolby, seconded by Mr. D. Adamson, it was resolved that Mr. Raymond Crane, F.C.A., of 46–47, London Wall, London, E.C., be re-elected to audit the accounts of the Institution for the present year at a remuneration of fifty guineas.

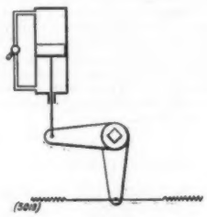
Alternating Stress Experiments.

A paper bearing the above title was next read in abstract by the author, Mr. William Mason, D.Sc. of the University of Liverpool, associate member. We commence the publication of this paper in full in another part of the present issue, and may therefore at once proceed to the discussion.

Mr. R. G. Batson, who spoke first, congratulated Dr. Mason on overcoming the many difficulties incidental to the construction of a machine to test material under combined alternating bending and torsion. Although the author had not presented any result, under combined stresses, the machine was, as had been stated, designed for that purpose. Dr. Mason had followed, more or less, on the lines upon which Mr. Bairstow, of the National Physical Laboratory, had worked in his researches in the cyclical variations of stress in iron and steel. The investigation had not afforded a rapid method of determining the limiting range of stresses in a material, but it was very satisfactory to learn that Dr. Mason had found Guest's law to hold good for alternate bending and torsion. In published results obtained at the National Physical Laboratory by the use of a method (suggested by Mr. Bairstow) differing entirely from that employed by Dr. Mason, Dr. Mason's conclusions, particularly in regard to Guest's law, were confirmed; and, if the Institution considered it desirable, the speaker would be glad to describe the method in a written communication upon Dr. Mason's paper.

Mr. C. H. Wingfield said it might be of interest if he endeavoured to illustrate, by mechanical analogy, the fact that the strain becomes less with rapid alternations. Such an analogy would not, of course, represent all the facts, nor was he himself aware of all these facts; it represented only certain stresses. He would suppose the plasticity of the specimen under test to be represented by the motion of a plunger in a cataract cylinder, the arrangement being illustrated by a sketch on the blackboard. In this sketch, which we reproduce in the annexed diagram, the cataract cylinder is assumed to be full of oil, and its two ends are connected by a by-pass pipe provided with a tap. The piston is connected by a rod to a lever mounted on one end of a short shaft which is to be regarded as the specimen under test, the other end of the specimen having mounted on it another lever which projects downwards as shown, its lower end engaging with a spring device which can be pulled backwards and forwards. When this latter

device is moved slowly, the tap on the cataract cylinder being partially closed so as to oppose resistance to the movement of the piston, the arrangement is representative of the application of a torsional stress on the specimen, and the piston will move a certain distance representing the amount of strain. If the speed of movement of the spring device to and fro be increased there will not be time for so much of the oil to be transferred from one end of the cylinder to the other during each application of stress, and the movement of the piston will therefore be less, thus indicating a less amount of strain. Increasing the speed still further, the angle through which the levers pass would be again diminished,



reducing the amount of strain indicated, exactly as the author had found in the case of his experiments. The mechanical analogy failed, however, in not showing why the range diminished with a constant amount of stress. The well-known reciprocating test machine by Captain Sankey—one which acted by slow motion—showed distinctly that a specimen when twisted backwards and forwards hardened, as the author had expressed it, and became stiffer and more difficult to twist. That was an everyday experience, as evidenced by the fact that a bit of copper, when twisted backwards and forwards, would become stiff. In the same way it would move a less distance to give the same compression in the spring.

The president remarked that he had found the paper a very difficult one to read, nor was he sure that he quite understood it. He had been most struck by the statement that the strain, near the breaking-point, could be continued for a very large number of revolutions as compared with the strain near the limit of elasticity. This idea was quite new to him, and he had hoped that some member present would have proffered a theory in relation to the occurrence. He understood that the experiments were to be continued, and, that being so, he trusted that the principle of procedure would be the sound one of one variable at a time. In the experiments under discussion, not only was the speed varied, but in some instances the stress; this, he thought, was matter for regret. No doubt sudden changes of speed and stress showed phenomena which were of great interest to scientists, but what practical engineers desired was to be able to make a prediction as to the life of a piece under stress. By long experience railway engineers had arrived at the length of time a crank axle ought to run, and when it had run that time it was taken out and carefully examined. The speaker's personal experience had led him to conclude that there was certainly some connection between the stress and the life, *i.e.*, the higher the stress the shorter the life, while the lower the stress the longer would be the life. He was very much inclined to think that there was really no limit as to the smallness of the stress at which a piece would break if the stress were put on a sufficient number of times. He believed that if a series of experiments were made at a given stress and a given speed, the stresses then being increased at the same speed, to see how many revolutions the piece would bear, a series of curves would be produced which would be extremely useful, showing only one variable at a time. The explanation offered by Mr. Wingfield did not, of course, entirely meet the case, which, however, was a somewhat weird case; it almost seemed as if there was something in the suggested relations whereby every piece of matter was supposed to have a soul. It would appear that the pieces of steel tested had a great objection to being hurried; given time, they would break, but if the attempt were made to hurry them they would not. On this point clearer explanation was needed.

Dr. F. Rogers, of Sheffield, regarded as important the fact that Dr. Mason had dealt with both the plastic and elastic ranges of steel. At the same time, all were fairly convinced that in the elastic range of stress there was also a hysteresis loop, an elastic, or recoverable, strain. One thing was clear from Dr. Mason's work and that of others, namely, that as research proceeded the stress at which plastic deformation began to show was lower and lower every year. Methods of discovery had become finer, and he thought everyone would agree that Mr. Mason had made a great effort, in his mechanism, to meet all the refinements which, at the present time, could possibly be foreseen, so as to get his stresses well under control and his means of measuring the strains accurate. In this connection he would refer to the author's remark that mild steel would endure a very large number of repetitions of a range stress—considerably greater than the range at which the extra-elastic strain appeared—that induced a considerable range of extra-elastic strain. That, the speaker observed, would be so if the steel were a good one. The steel subjected to experiment was a very mild steel, very low in carbon, lower, in fact, than was nowadays commonly used except for a very few special purposes. The speaker was, incidentally, interested in the steel because it was one of the British Association steels which he had been instrumental in obtaining for his own committee. It was also a very important point, as possibly Dr. Mason had to a certain extent recognised, that in the early stages of inelastic strain—occurring with the first appearance of any strain at all—the strain was mainly in the ferrite constituent of the steel. All were well aware that the steel consisted of a sort of concrete, approximately one part of ferrite, or pure iron, mixed with something like 0.9 per cent. carbon steel. He was not quite sure whether Dr. Mason had used that steel in the annealed condition or not, although, from the speaker's knowledge of the manufacture of the steel, it would not make any difference whether the steel were used as rolled or in the annealed condition. To return, however, to the point of importance, the first inelastic strain occurred in the ferrite, the soft iron which was the main component of the steel. It was on this account that, given reasonably good material, the steel would bear frequent repetitions of the inelastic strain. There was in that a parallel with the good old-fashioned material known as best wrought iron, practically wholly pure ferrite iron. It was known that that material might be repeatedly and visibly overstrained, and yet have a wonderfully long life. He brought this point to the notice of the meeting, the better to visualise the importance of the structure of the material as seen by the microscope, and to show that structure was not a mere fanciful theory but a thing of everyday practical importance. With regard to microstructure, he would like to refer to Fracture D shown in Fig. 16 of the paper. That fracture appeared to be extraordinary, and from his own experience he would say that in a material of that class it was typical only of what could be obtained by continued torsion, and it would be very difficult to produce the fracture in any other way unless the material were in an extraordinarily unusual condition. He thought it might be assumed that the heat-treatment was in every way normal, an assumption supported not only by Dr. Mason's experiments, but those of other investigators. The result of a tensile test of the material, quoted in the paper, also established the fact that the steel must have been of good, tough and mild quality. He would like, finally, to emphasise his opinion that the machine used was the right one for the work.

Dr. Mason then replied to the discussion, stating that he would be very glad if Mr. Batson would submit the results of the tests he had mentioned. He assumed that those tests were carried out on British Association steel, and the speaker would like, if possible, to have the stresses and elastic limits which had been found in his own experiments confirmed by others. Mr. Wingfield's mechanical analogy, while a good illustration, broke down at the point perceived by that gentleman; it could not be carried further, and was only exact for the effect of variation of speed; it did not account for the contraction by strain at constant speed. With regard to the president's remarks as to keeping only one variable at a time, maintaining the rest constant, he would say that, as far as possible, he had endeavoured to carry out that idea from the start; he had, however, been surprised to find the speed effect so large. At first realisation of that effect he had thought there must be some large inertia effect in the machine. He had, therefore, considered that, in seeking the whereabouts of the leakage of strain, the first thing to do was to investigate the effect of change of speed, especially in view of the additional difficulty which occurred, a difficulty represented by the point of breakdown of Mr. Wingfield's mechanical analogy. In the first instance he had intended to slow down the machine and take measurements of the strain throughout the cycles of stress, thinking that there would be very little difference between the cycle of strain at the low speed and that at the high speed. He had, however, found this impracticable. In order to carry out his idea (which Mr. Batson had suggested was initiated by Mr. Bairstow) but which, in fact, was attempted about 1870), and to follow up his intention of measuring the strain throughout the cycles, it was necessary to know the effect of variation of speed, and he therefore felt justified in having departed from the main work, and in obtaining the conclusions arrived at concerning the state of the steel at different speeds. The one-variable method had been that employed in alternating stress tests from the outset, and while he had intended to keep to the beaten track, he had found that, on the whole, it was better to diverge from it. He had understood Dr. Rogers to say that the range of stress at which the specimen broke was, with the progress of time, getting smaller and smaller, owing to the greater delicacy of the apparatus used and the greater prolongation of the tests. The speaker's personal experience, however, reversed that conclusion. With a thousand million repetitions of stress, less than 5.5 tons per square inch, in torsion, there would be no change in the steel; it would be the same at the end as at the beginning.

The president then closed the proceedings with the announcement that the next ordinary general meeting would be held on Friday, March 16 next, when two papers would be read, one by Sir William Beardmore on the "Heat-Treatment of Steel," and another on the same subject by Mr. Ashdown.

Benevolent Fund.

The meeting reported above was followed by a meeting of the Benevolent Fund, at which the business transacted was almost wholly of a formal character. In submitting the report of the committee for adoption the president made the following remarks. He said that he greatly regretted the fact that the membership of the Fund was so small. Only 4 per cent. of the members of the Institution belonged to the Fund, and as the number of members of the Institution exceeded 6,000, it was plain that a very small subscription from each member would yield a very large and effective fund. He thought the Benevolent Fund should rely more upon annual subscriptions than upon the accumulation of large capital; every generation should bear its own burdens. At the outset the idea had been to raise a capital fund of 10,000*l.*, but as yet the amount was very far from that. The accounts showed a capital of 6,000*l.* He had, however, to remind the members that that was the nominal value of the capital, *i.e.*, the value which it cost. If the income derived from that capital were multiplied by twenty—about the right proportion at the present time—it would be found that the real capital was only about 4,200*l.*, and, while he hoped that the capital fund would be added to, he was anxious that more members should contribute even if they contributed only very small sums.

London, Brighton and South Coast Railway.—Mr. C. L. Morgan, who was appointed chief engineer to this railway company in 1896, is now relinquishing that office to take a seat on the board. He is replaced by Mr. J. B. Ball, who has been engineer-in-chief of the Great Central Railway since 1911.

WATERSPOUT.

We are indebted to the director of Messrs. Gio. Ansaldo and Co., of Sestri Ponente, Italy, for the accompanying photograph of a waterspout which appeared over the Mediterranean on January 13, about

a third of a mile from their shipbuilding yard. The photograph gives an excellent representation of this somewhat unusual meteorological phenomenon, and enables one to realise the dread of the old sailing-ship captains of being overwhelmed by the mass of water when the spout bursts.

"SCREW THREAD MEASUREMENT."

To the Editor of Engineering.

Sir,—In your issue of February 2, 1917, page 113, you publish a paper read by Mr. Arthur Brooker before the Liverpool Engineering Society on "Screw Thread Measurement." After discussing the absence of apparatus for accurately measuring gauges the author states:—"No measuring instruments were purchasable, but the National Physical Laboratory gave sufficient information to enable such instruments to be made . . ." We venture to point out that we designed, in conjunction with Dr. Glazebrook, such a machine on behalf of the Small Screw Gauge Committee of the British Association, and which is described in the appendix to the report of the committee contained in the report of the Southport meeting of 1903; it was also fully described and illustrated in Engineering for November 13, 1903. It was again illustrated in Dr. Glazebrook's paper on "Limit Gauges," read before the British Association last year, It will be found illustrated on page 252 of your issue for September 15, 1916.

Duplicates of this machine were supplied before the war to the Royal Arsenal, Woolwich, the Japanese and Australian Governments, and to several firms, amongst which may be mentioned Messrs. Ludwig Loewe and Co., of Berlin, as showing that the machine was known outside this country.

As far as we can judge from an examination of the illustration of Mr. Brooker's machine it seems to be similar in many points to our machine. We, however, write this letter in order to point out to your readers the value of the work done by the Small Screw Gauge Committee of the British Association and the National Physical Laboratory in making it possible to measure accurately all the important quantities in screws. The value of the work done by the National Physical Laboratory consisted in realising that a screw-measuring machine was wanted, and what it would measure, and we merely carried out the design to the best of our ability. They have now added to the value of their work by showing how very simple apparatus can be made which will accurately measure screws.

Yours faithfully,
The Cambridge Scientific Instrument Company, Limited.
(Horace Darwin, Chairman.)

Cambridge, February 19, 1917.

ELECTRON, QUANTA AND RELATIVITY THEORIES.

To the Editor of Engineering.

Sir,—In a moment of forgetfulness Mr. Edwards charges me with being under the impression that his letters are confined to replies to my "very indefinite questions," whereas I have been most careful to state the exact opposite; and my question about the ray is really so definite that Mr. Edwards finds it convenient to withdraw from the discussion with still another quotation from Maxwell which is no reply to what I asked.

"A ray of light is also a ray of heat," said Mr. Edwards, on page 63 of your issue of January 19; so I at once inquired (page 79) what its temperature might be, and we were told the calculated temperature of interstellar space. Then I pointed out that "it is the *ray*, not the *space*, that raises the temperature of things"; and now I am accused of asking "for the temperature of a ray of heat without specifying the particular ray"—Mr. Edwards's very own ray, the one he introduced, and the only ray about which any question has been asked. It is too bad!

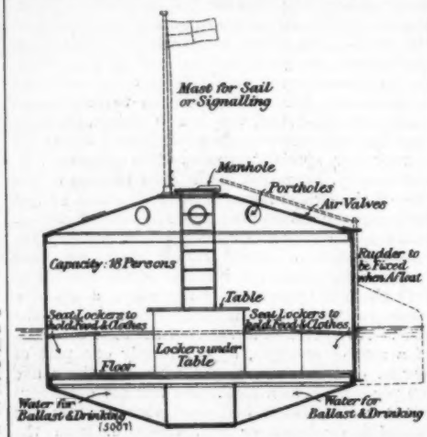
February 17, 1917. "Sesamy."

LIFE RESCUE FROM TORPEDOED MERCHANT VESSELS.

To the Editor of Engineering.

Sir,—We are daily and increasingly distressed by reading of the sufferings in open boats—but *why* open and why not a globe such as was successfully tried some ten years ago?

Surely, in these days of wireless and of patrols, it is shelter which is needed and not mere sailing power!



Let us adjust our ideas to the altered circumstances. I submit that with two of such vessels in addition to the long-overdue guns, and with perhaps a conning tower for the helmsman, our merchant service might have better support for their gallant equanimity.

I venture to send a sketch which may serve to recall the original vessel to some of your readers or even form a basis for a proper design. With the present season, anything to be done should be done quickly, and any spare navigation buoys might be quickly adopted for a start.

Yours faithfully,
F. W. D.

"SKILL AND PAYMENT."

To the Editor of Engineering.

Sir,—In your well-written leader "Skill and Payment," of February 2, there does not appear to be an adequate answer as to why draughtsmen, as a body, are underpaid commensurate to their skill or responsibility. To me, the real issue seems to have been side-tracked by the writer's academic handling.

The second paragraph of "Tee Square's" letter in a subsequent issue comes much nearer the mark.

Of recent years, unions of different trades have developed, and exist as we know them. Draughtsmen are now forming one of their own. What has brought about the necessity of this?

Is it due to the imposition and greed of employers? Is it due to the exploitation of labour by capital? Or is it the ordained solution of industrial problems? Accepting the latter as the true hypothesis, then it seems to me that we are very slowly, but none the less surely, approaching a time when those ubiquitous interlopers—favouritism and influence—will not enjoy the same freedom as of old. At the present time, of all trades, that of engineering is absolutely soaked with them in all its branches. Granted that all of us cannot rise to the top—and a vast number are waiting for dead men's shoes—it is rather humiliating to an experienced and qualified man to have some favoured and influenced individual placed over him: the matter of competence being a minor consideration. But this aspect of the question is applicable the world over. Speaking broadly, it is not entirely necessary for heads of our big concerns to know all about the business which they control. Their real and immediate business is to engage those who can do their business for them. That is at the top of the ladder. Those people have a social and financial standing. And they have also some friends! These are generally looked after. All the trouble is with those at the bottom; that is where all the jostling takes place. So, with regard to an engineering works, on which rung of the ladder does a drawing office stand? The place where the embryos of its manufactures are developed! Really, when one recalls to mind for a moment some of the advertisements which have appeared in your columns in the past, the salaries which have sometimes been mentioned provoke ridicule and disgust when compared with the qualifications expected. Such can have been sent for insertion only by those utterly ignorant of "relative value."

Those draughtsmen who have come to the stage of controlling very responsible work involving much technical skill are certainly not too well paid. Be the reason what it may, sooner or later this part of the business will be improved, and it looks as though unionism is the only solution to the problem. The instances where highly skilled draughtsmen are adequately paid are conspicuous by their exception; but it would be highly interesting if any correspondent could throw some light on "why the powers that be" have, in the large majority of cases, assessed our faculties at such a woefully moderate figure?

Perhaps they see in some of us "an artist's soul without the skill of craft," quite content to eke out a living in some back garret or another.

So to throw off the yoke of all the shortcomings under which we now labour, consolidate, for it is the only way to obtain some recognition. It is of little use dwelling on the inconsistencies which exist; the immediate plan is to remedy them. We can console ourselves a little in the thought that the engineering part of this war is, to a certain extent, being fought on the drawing boards of Great Britain and Germany. Any solatium which may be forthcoming in the future may be due to our efforts *now*.

Yours truly,
J. H. B.

"THE LUMEN UNIT OF ILLUMINATING POWER."

To the Editor of Engineering.

Sir,—My attention has been called to an error in my letter to you on pages 137 and 138. I stated that "lamp-makers have agreed to rate electric lamps, not in candle-power, nor in watts, but in lumens." The words "nor in watts" should be omitted.

Yours truly,
A. P. Trotter.

181, Ashley-gardens, S.W., February 19, 1917.

To the Editor of Engineering.

Sir,—I have read with considerable interest and appreciation your editorial of your February 2 issue, page 108, on the "lumen," and am grateful to you for an able presentation of the need of a new unit such as the lumen for expressing luminous values. There appears to have been a misunderstanding on the part of some with reference to the rating of electric lamps, and this error—now corrected in his later letter—was made in Mr. A. P. Trotter's letter to you which appeared on page 137 of your issue of February 9. I should appreciate the courtesy of your columns to make a statement to set the matter right.

The proposal to adopt the lumen as a unit for luminous values does not in any way affect the basis of practical size rating of electric lamps by total watts which has been, and is to-day, the standard and accepted practice of leading manufacturers, and is also confirmed by the Engineering Standards Committee. The reasons for the size rating by total watts which have standardised it as the fixed size rating were given in the paper presented by the writer before the Illuminating Engineering Society in April, 1915, entitled "The Practical Rating of Electric Incandescent Lamps."

The proposal to use the lumen as a unit for luminous values has nothing to do with practical size rating by total watts except to supplement it for those cases where the user or engineer desires the luminous values given by the lamp to work out illuminating problems. The lumen is, therefore, proposed as a unit for luminous values where luminous values are to be used, and it is not to replace, but merely supplement, the present very satisfactory size rating by total watts for electrical incandescent lamps.

Yours very truly,
F. W. Willcox.

"Mazda House," 77, Upper Thames-street,
London, E.C., February 20, 1917.

Personal.—Messrs. Siemens Brothers and Co., Limited, and Messrs Siemens Brothers' Dynamo Works, Limited, have removed from Caxton House, Westminster, to Palace Place Mansions, Kensington-court, London, W. (Station—High-street, Kensington).

Underground Waste in Oil and Gas Fields.—If the hopes of oil discoveries in this country should be realised, it is most desirable that the exploitation, like the search, should be conducted in a systematic, scientific way. The injudicious utilisation and tapping of water has done serious harm to whole districts, and the dangers are much greater, of course, in the case of natural oil and gas. Technical Paper 130 of the U.S. Bureau of Mines, by Messrs. W. F. McMurray and James O. Lewis, deals with this question. Water gaining access to oil sands may hopelessly drown them; the natural gas may collect in some pocket, but that locality may be difficult to find. When big gas fields are struck there may be no preparation for catching the gas; to allow it to escape rapidly may spoil all the wells, as underground migration may be set up. In parts of California oil sands are drilled with oil—instead of water—in the hole. To prevent escape of gas and the rise of water in the space between the casing and the hole wall, from which space the water might flow into upper strata and submerge the field, packers of cement are arranged round the casing, or the mud-laden fluid method of Pollard and Heggem is applied, the latter with considerable success. It is to be hoped that haphazard operations will not be permitted in this country.

ALTERNATING STRESS EXPERIMENTS.*

By WILLIAM MASON, D.Sc.,† of the University of Liverpool (Associate Member).

THE main feature of these experiments is the systematic measurement of cyclic strains during complete alternating stress tests. The tests were of mild steel in alternating torsion and in alternating bending.

Machine used in Experiments.—The machine has been designed by the author to make tests on specimens under repeated torsion, or bending, or under repeated torsion and bending simultaneously. It is a slow-speed machine; the work already done by its aid being at frequencies either less than, or very little exceeding, 200 cycles per minute. It appeared that measurement of cyclic strains and convenience in changing the frequency of the cycles without stopping and without alteration of stress would be best obtained by adopting a slow speed. At such slow speeds as the above, vibration of the specimen and of the strain-measuring apparatus may be made negligible.

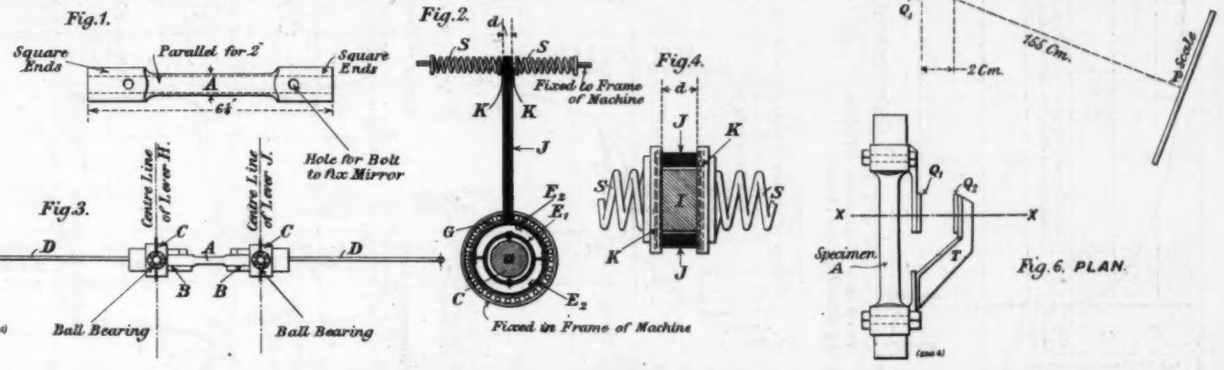
The specimen A, Fig. 1 (above), is secured between grips B, Fig. 3, which are keyed to the square ends of the specimen before it is put into the machine. These grips are bolted between the faces of a pair of sockets C fixed in the machine (Figs. 3 and 5, above). The method of gripping and fixing in the machine ensures that the specimen is quite free from initial indeterminate stress. Each socket C is capable of partial rotation upon a vertical pivot of ½-in. diameter hardened steel. The ends of these pivots are secured in steel rings E_1 (Fig. 2), while E_1 may rotate upon a horizontal ball-bearing pivot which is fixed in an outer ring E_2. The horizontal and vertical pivots thus form a gimbal-joint supporting the socket C at its centre. The outer ring E_2 is surrounded by a ball bearing G, the exterior of which is fixed in a casting bolted to the frame of the machine. A vertical aluminium lever is bolted to the ring E_2 of each gimbal-joint; the end of one of these levers H (Fig. 5) receives an oscillatory movement whose amplitude may be varied to any required degree of fineness while the machine is running; the end of the other aluminium lever J is held in position by the springs S S (Figs. 2 and 5, below). Thus the lever H tends to twist the specimen against the measured resistance of the springs S.

The mode of action of these springs will be seen by reference to Fig. 4, which is a diagrammatic plan looking vertically down upon the top of the vertical lever J. J is in two halves, the halves being bolted to opposite vertical faces of E_2, and thus rigidly connected together. Between the tops of these two halves, but not touching either, is the block I, which is fixed by an adjusting screw to the frame of the machine. The dimension *d* (Figs. 2 and 4), is the same exactly as the breadth of I and the breadth of the halves of J. Knife-edges K K are pressed by the springs S S upon J and I. When torque is put upon the test-piece A by the lever H, the top end of J tends to move against the pressure of one (or the other) of the springs S, but movement of J cannot occur until the whole force of this spring is exerted upon J, and the block I entirely relieved of pressure from this spring.* The maximum torque upon the specimen is thus measured by the force of compression in S multiplied by the length of the lever J.

A bending moment, uniform over the length of a specimen, may be applied by a pair of levers D (Figs. 3 and 5, below), of equal length, which are keyed into the cores C (Figs. 2 and 3) of the gimbal-joint. The horizontal ball-bearing pivots (already mentioned) between the rings E_1 and E_2 form the fulcra for the levers D. The outer ends of these levers receive a vertical oscillatory movement, and the amount of the bending movement given by them to the specimen is regulated by control springs R (Fig. 5), in a manner similar to that already described for the torque.

All the fittings described are in duplicate, so that two specimens may be tested at the same time.

Accuracy of Measurement of Torque and Bending Moment.—When the springs S (Fig. 2) have been screwed down by a calibrated amount required for a given torque, the amplitude of movement of the lever H is increased until the knife-edges K just lift away from the block I on either side at each to-and-fro maximum of the amplitude. In working, the amount of this lift on either side is shown by the breadth of the streaks of light from a lamp appearing between the knife-edges K and the block I. During tests, especially at very slow speeds, the lift, shown by the breadth of the streaks, is allowed, for the sake of convenience, to vary a little. As "fatigue" progresses, non-elastic cyclic strain



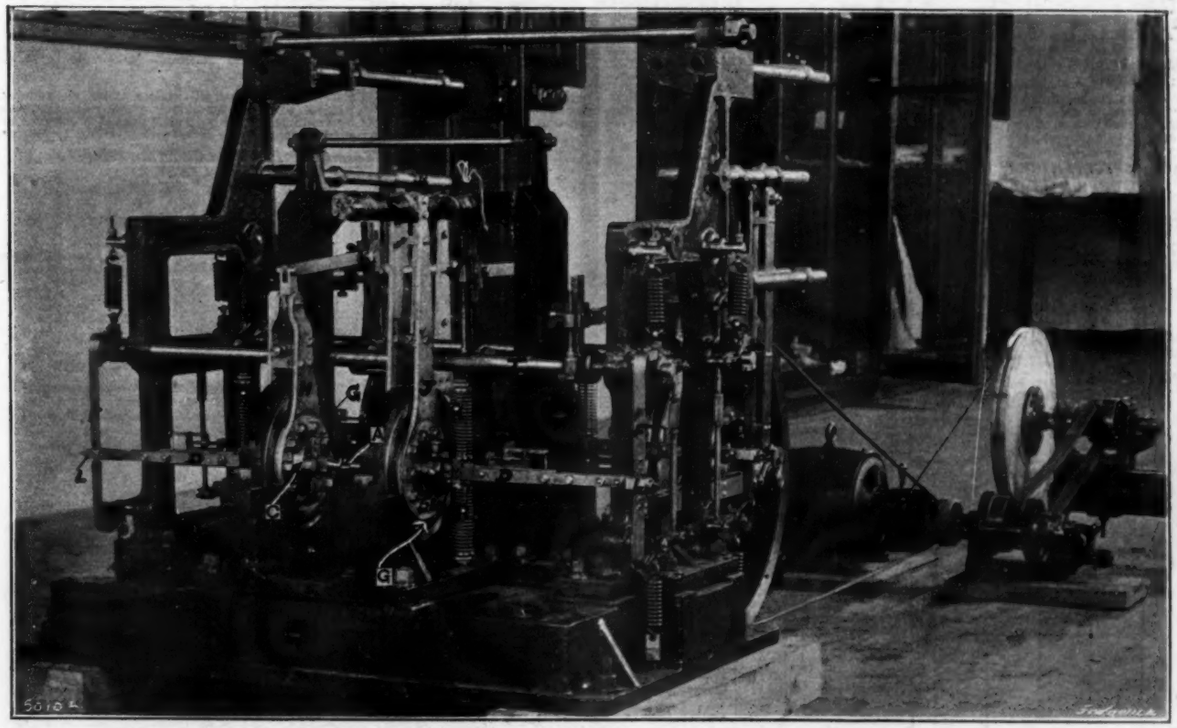


FIG. 5. SLOW-SPEED ALTERNATING STRESS MACHINE.

* Paper read before the Institution of Mechanical Engineers, Friday, February 16, 1917.

† Received Bryan Donkin Fund awards in 1910 and 1913.

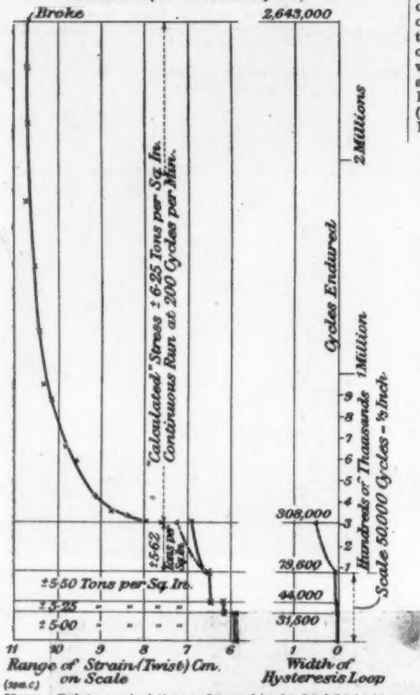
* This spring device is similar to that used by Wöhler for measurements of stress in some of his machines.

increases, as shown by Bairstow.* This increase is shown by decrease of lift of the knife-edges K if the amplitude of motion of H remains the same. Since it is not always convenient to visit the machine at frequent intervals in order to regulate the amplitude of H, and so keep the lift of J exactly constant, the author has been accustomed, upon occasions when the change of cyclic strain is slow, to increase the amplitude of H so that the lift of J is a little above the normal working amount, and to leave the machine at work without attention for a period. The lift of J then gradually decreases with the increase of cyclic strain. This variation of lift means a variation of stress so small as to be negligible in comparison with the total stress applied. The springs S have a stiffness of 11 lb. per inch of axial deflection. For example, with the springs screwed down to 12 lb. compression, and the torque therefore $12 \times 16 = 192$ in.-lb.—J being 16 in. long—a variation of lift of $\frac{1}{10}$ in. could be allowed (at very slow speeds) with a variation of torque of 1.75 in.-lb., or about 1 per cent. This was more than the extreme variation allowed in the experiments described, though, when change of cyclic strain was very slow, the author has left the machine without attention for 36 hours. A lift of $\frac{1}{10}$ in., as seen by the streak of light between K and I, looks large. It may be noted that a variation of ·1 per cent. would correspond in a rotating mass, or reciprocating mass testing-machine, to a variation of speed of half of 1 per cent. With a speed of 200 cycles per minute the variation of lift allowed was less, since the inertia of the lever J then becomes appreciable.

The inertia of the lever J about the axis of the specimen, and the effect thereof upon the measured torque, were calculated in designing the machine. Careful experiments have been made to ascertain the increase of torque, due to this inertia, imposed upon the specimen for a change of speed from 2 to 200 cycles per minute. In the case of specimen No. 27 (see Appendix) the calculated increase of torque for the above difference of speed is a little over 1 per cent. for the case when the torque is 140 lb.-in., and the lift of the springs S 0.005 in. This increase agreed with the increase of range of strain measured under the above conditions, the elasticity of the specimens being practically perfect. With the movement of J, that is, the lift of the knife-edges K, of $\frac{1}{10}$ in., allowed at the maximum speed of 200 per minute used in the tests of this paper, it is improbable that the variation of torque with change of speed can have exceeded 1 per cent.

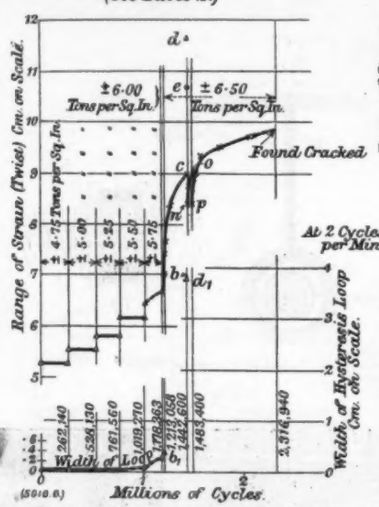
What has been said concerning the accuracy of measurement of torque applies generally, also, to that of the bending moment. There is a similar small increase of bending moment with increasing speed, which is small up to 200 cycles per minute, and is about 1 per cent. for the tests of this paper. In the case of specimen No. 29, Table 4, the increase of elastic deflection between speeds of 2 and 200 cycles per minute was measured. The lift of the springs was—as nearly as could be gauged—about twice the usual working amount,

Fig. 8. SPECIMEN B.22 (HOLLOW). ALTERNATING TORSION (See Table 2.)



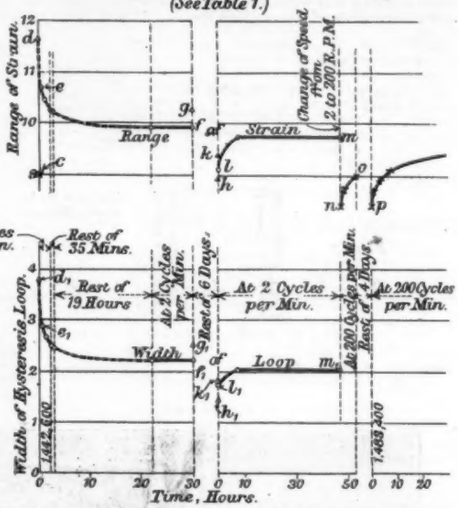
NOTE.—Points marked thus Δ observed in deadweight tests, the intermediate runs being at 200 cycles per minute. Points marked thus × observed during runs at 200 cycles per minute.

Fig. 9. SPECIMEN A. 10. (See Table 2.)


±6·00 Tons per Sq. In.
±6·50 Tons per Sq. In.
Found Cracked
Range of Strain (Twist) Cm. on Scale
Width of Hysteresis Loop Cm. on Scale
Millions of Cycles

NOTE.—Points marked thus Δ obtained by deadweight loading, the intermediate runs being at 200 cycles per minute. Points marked thus × observed during runs of 200 cycles per minute.

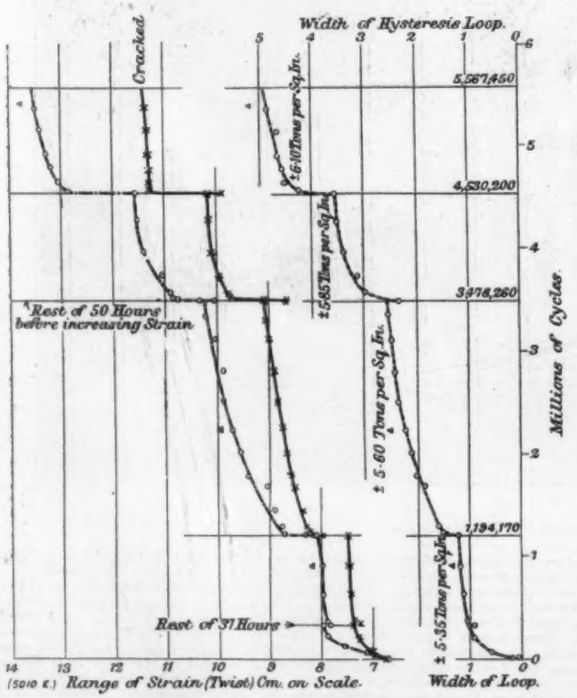
Fig. 9a. ALTERNATING TORSION. CURVE ILLUSTRATING TEST BETWEEN POINTS "c" AND "p" OF Fig. 9. (See Table 1.)



Points marked ○ observed while machine was running at 2 cycles (=2 r.p.m.) per minute. Points marked Δ obtained by deadweight loading. Points marked × observed while machine was running at 200 cycles per min. (=200 r.p.m.).

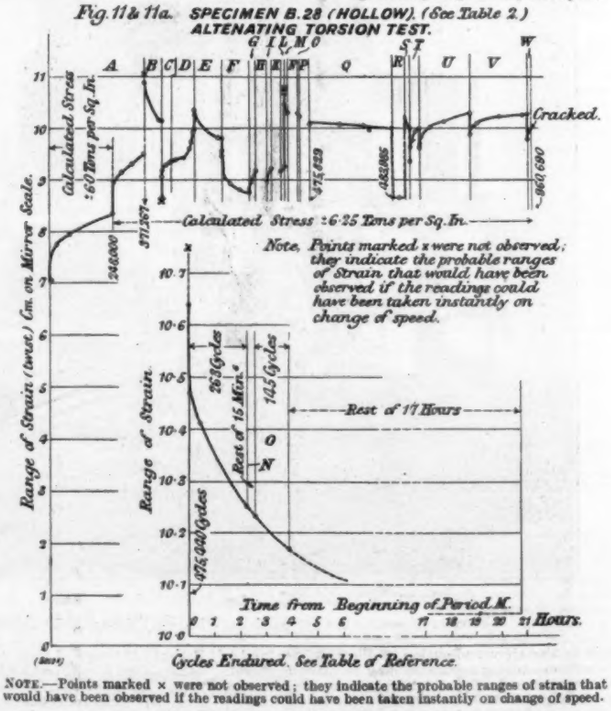
Fig. 10. SPECIMEN No. B.27 (HOLLOW). (See Table 2.) ALTERNATING TORSION TEST AT "CALCULATED" STRESSES MARKED BELOW.

TOTAL TIME OF TEST, EXCLUSIVE OF RESTS, 19 DAYS 3 HOURS.



Full line curve—Total range of twist between ends of specimen. Speed, 200 per minute. Chain dotted line—Total range of twist between ends of specimen after change from 200 to 2 cycles per minute. Dotted line—Width of hysteresis loop (= twist of successive halt periods of zero torque) after change from 200 to 2 cycles per minute.

Fig. 11 & 11a. SPECIMEN B.28 (HOLLOW). (See Table 2.) ALTENATING TORSION TEST.


Calculated Stress ±6·0 Tons per Sq. In.
Cracked.
Calculated Stress ±6·25 Tons per Sq. In.
Note. Points marked x were not observed; they indicate the probable ranges of Strain that would have been observed if the readings could have been taken instantly on change of speed.
Range of Strain (Twist) Cm. on Mirror Scale.
Range of Strain.
26 Cycles
145 Cycles
Rest of 15 Mins.
Rest of 17 Hours
475,040 Cycles
Time from Beginning of Period M.
Cycles Endured. See Table of Reference.

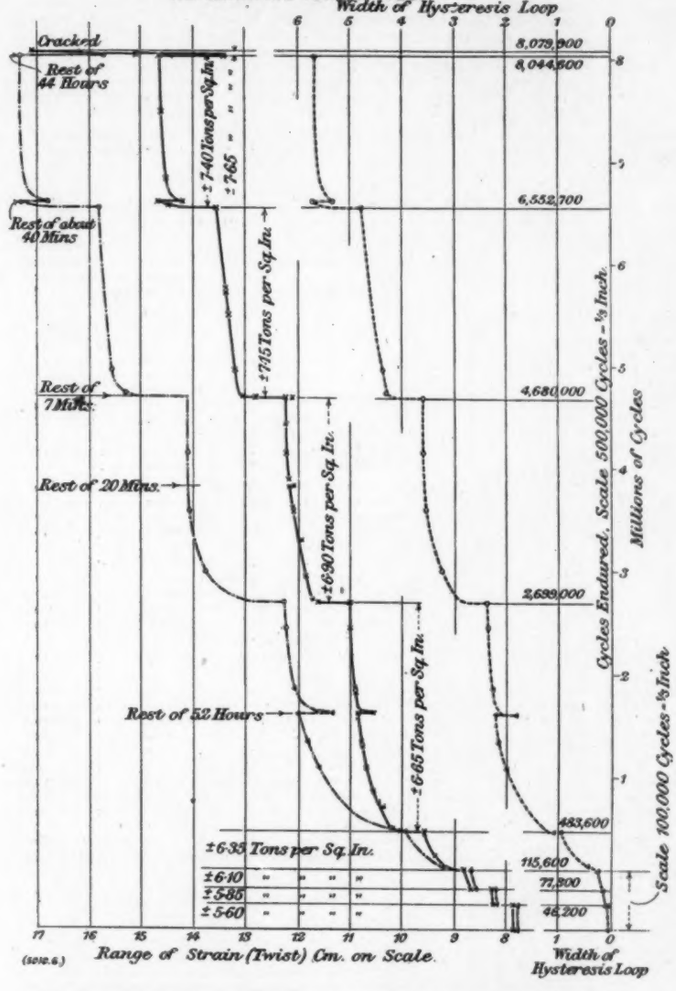
NOTE.—Points marked × were not observed; they indicate the probable ranges of strain that would have been observed if the readings could have been taken instantly on change of speed.

What has been said concerning the accuracy of measurement of torque applies generally, also, to that of the bending moment. There is a similar small increase of bending moment with increasing speed, which is small up to 200 cycles per minute, and is about 1 per cent. for the tests of this paper. In the case of specimen No. 29, Table 4, the increase of elastic deflection between speeds of 2 and 200 cycles per minute was measured. The lift of the springs was—as nearly as could be gauged—about twice the usual working amount,

* Phil. Trans. A. 210.

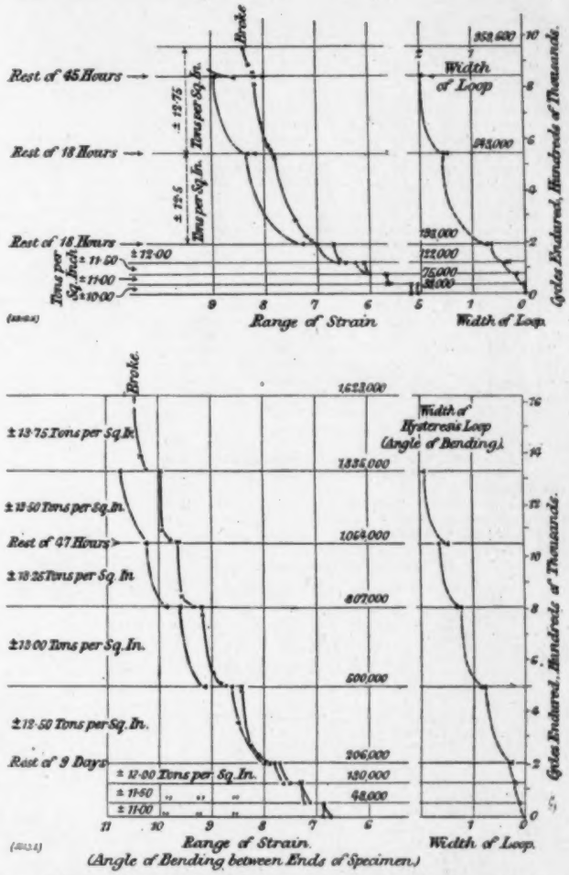
ALTERNATING STRESS EXPERIMENTS.

Fig. 12. SPECIMEN N°A.7 (SOLID). (SEE TABLE 3.)
ALTERNATING TORSION TEST.



Full line curve—Range of strain (twist between ends of specimen at speed of 200 cycles per minute). Chain dotted curve—Range of strain after change from 200 to 2 cycles per minute. Dotted curve—Width of hysteresis loop after change from 200 to 2 cycles per minute. NOTE—Points marked thus Δ obtained by deadweight loading.

Fig. 13. SPECIMEN A.15 (SOLID). ± BENDING. (See Table 4.)
Fig. 14. SPECIMEN A.16 (HOLLOW). ± BENDING. (See Table 4.)



Full line curves—Range of strain at 200 cycles per minute. Chain dotted curves—Range of strain obtained by imposing bending moments by deadweights, machine stopped. Dotted curves—Width of hysteresis loop, deadweights, machine stopped.

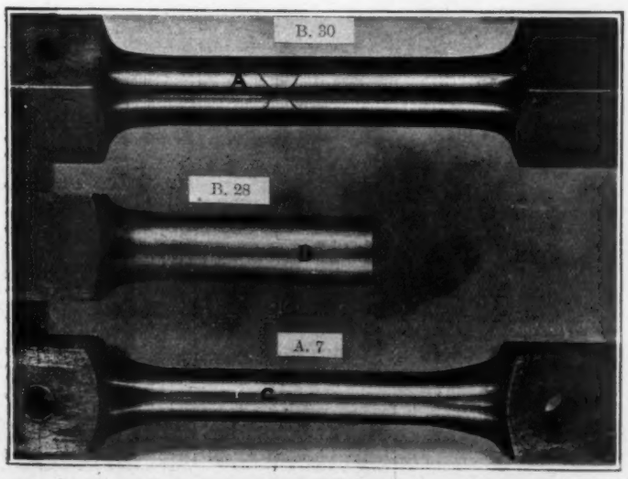


FIG. 15. SPECIMENS OF ALTERNATING TORSION FRACTURES. (SEE TABLES II, III, AND V.)

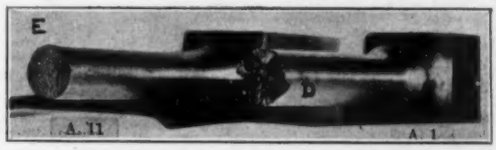


FIG. 16. ALTERNATING TORSION FRACTURE AT D; ALTERNATING BENDING FRACTURE AT E.

in order to obtain a larger difference for measurement; and the increase of bending moment corresponding to that of the elastic deflection was 1½ per cent.

The only friction which can have any action on the accuracy of measurement of the torque is that of the ball bearing surrounding that gimbal-joint to which the lever J is fixed (Fig. 2, page 187). When this ball bearing is free of the grease with which it is covered in normal working, the friction is negligibly small. The grease is put on, not for the purpose of lubrication, but to keep damp from the ball-race. The moment of the "sticktion" of the grease is just measurable. No attempt has been made to make correction for it. The friction of the ball-bearing pivots, about which the bending levers D work, is quite inappreciable.

Apparatus for Measurement of Strains.—Torsional strains are measured by an arrangement of mirrors fixed to the specimen by bolts passing through the holes in the square ends shown in Fig. 1. The specimen is held horizontally in the machine. A mirror Q_1, whose plane is vertical, is secured to one end of the test-piece; a second vertical mirror Q_2 is carried by an arm T (Figs. 6 and 7), which is bolted to the other end. Q_1 and Q_2 face each other, and are about 2 cm. apart. Both are parallel to the axis of the test-piece. Fig. 7 is a vertical section through the line X X of Fig. 6. R is a fixed mirror (not shown in Fig. 6), which is merely used for convenience of keeping the telescope and scale on the same side of the machine. The scale is 155 cm. from Q_1, as shown in Fig. 7. As the specimen is twisted, the mirrors Q_1 and Q_2 alter their relative inclination; and the range of travel of the point P on the scale is proportional to the total angle of twist during a cycle of stress.

A similar arrangement, with two mirrors fixed to the specimen in vertical planes perpendicular to the axis

of the specimen, enables the angular bending deflection between the ends of the specimen to be observed by means of another telescope and scale.

When a specimen is under alternating torsion, or alternating bending, the image of the scale travels vertically to and fro across the horizontal cross-wire of the telescope, and the difference between the extreme readings of the cross-hair are thus proportional to the range of the strain. At speeds up to about 30 per minute the extreme readings of the cross-hair may be read directly. At higher speeds the motion of the image in the field of the telescope is too rapid for the scale divisions to be read directly; and the method of obtaining the upper and lower readings of the cross-wire is the following:—A black cover, fitted to slide along the scale, is provided with a narrow transverse slit, through which the white surface of the scale may be seen. The slit is illuminated by a lamp; and the black cover is slid along the scale until the image of that edge of the slit nearer to the middle of the travel coincides with the cross-wire of the telescope. At speeds approaching 200 per minute the image of the slit is distinct only at the ends of its range of motion; the approximately simple harmonic character of the motion, aided somewhat by persistence of vision, then enables the edge of the slit to be observed. The two positions of the slit on the scale corresponding to coincidence of its edge with the cross-hair give the readings whose difference is proportional to the range of the angular strain.

Material Tested—The material of the tests has been provided by the Complex Stress Distribution Committee of Section G of the British Association. It is a "dead mild" steel of 0·12 per cent. carbon. The bars furnished to the author were ¾ in. square. A direct tension test on a specimen turned to 0.623 in. diameter for a gauge-length of 4 in. gave a yield-point 14.6 tons per square inch, a maximum stress $\left(=\frac{\text{maximum load}}{\text{area of bar}}\right)$ of 23.5 tons per square inch, and an elongation of 35.5 per cent. taken on 4 in. A torsion test on a solid bar turned to 0.372 in. diameter gave a yield-point of 9.90 tons per square inch shear stress.

The specimens tested were cut from either of two bars, which are distinguished by the letters A and B. The numbers given to the specimens indicate the order in which they were cut from these bars. The material was not heat-treated in any way by the author.

Table of Reference for letters on Fig. 11.

Letter on Fig.	Period Denoted by Letter.	Duration of Period.	Speed during Period.	Scale of Plotting of Cycles Endured.
	From	hrs. min.		cycles. in.
A	0 to 371,267	31 0	200 per min.	200,000 = 1
B	371,267 to 372,935	14.8 0	2 per min.	5,000 = 1
C	372,935 to 411,580	3·2 0	200 per min.	200,000 = 1
D	411,580 to 413,935	0 42	Speed decreasing from 200 to 2 per min.	5,000 = 1
E	413,935 to 416,600	23.4 0	2 per min.	5,000 = 1
F	416,600 to 419,300	0 38	Speed increasing from 2 to 200 per min.	5,000 = 1
G	419,300 to 445,268	2.2 0	200 per min.	200,000 = 1
H	445,268	17 0	Rest	—
J	445,268 to 463,296	1·5 0	200 per min.	200,000 = 1
K	463,296	0 15	Rest	—
L	463,296 to 475,432	1 0	200 per min.	200,000 = 1
M	475,432 to 475,702	2.4 0	2 per min.	5,000 = 1
N	475,702	0 15	Rest	—
O	475,702 to 475,829	1·12 0	2 per min.	5,000 = 1
P	475,829	17 0	Rest	—
Q	475,829 to 483,985	72.2 0	2 per min.	5,000 = 1
R	483,985 to 485,090	0 5.5	200 per min.	5,000 = 1
S	485,090 to 485,585	4.4 0	2 per min.	5,000 = 1
T	485,585 to 523,822	44.2 0	14·4 per min.	200,000 = 1
U	523,822 to 723,450	118.5 0	28.1 per min.	200,000 = 1
V	723,450 to 945,300	52.9 0	70 per min.	200,000 = 1
W	945,300 to 960,690	1·25 0	200 per min.	200,000 = 1

The Torsion Tests.—The behaviour of the material under repetitions of cycles of torsion of equal maximum torque in either direction of twist may be explained by reference to Figs. 8 to 12. Specimen B 22, Fig. 8, was given a number of cycles at each of a series of low ranges of stress. Its elasticity was, so far as could be observed by the apparatus for strain measurement, sensibly perfect until the range of stress was ± 5.50 tons per square inch. At this stress the width of hysteresis loop and the range of twist showed slight increases;* and at ± 5.62 tons per square inch (calculated from the torque by the formula which assumes perfect elasticity) it was evident that an elastic limit for cyclic applications of this stress had been passed. The range of torque was then increased to give ± 6.25 tons per square inch "calculated" (as above) stress; the range of twist now became greater very rapidly. After about 1¼ million cycles at this range of torque the range of twist had appeared to attain a maximum value, and after a total of about 2½ millions at this range of torque the piece cracked. These cycles at ± 6.25 tons per square inch were imposed at the speed of 200 per minute and without stop or interruption of any kind.

The effect upon the range of torsional strain of rest and of change of speed of cycle is illustrated by the test of A 10, Figs. 9 and 9a, and Table I. In this test there was an elastic limit under repeated torque at or very near ± 5.50 tons per square inch; after a run at ± 5.75 and a short run at ± 6.00, the range of ± 6.5 tons per square inch "calculated" stress was imposed, and the range of torque corresponding to that "calculated" range of stress was kept unchanged until the end of the test; Table I shows the series of operations done during the stage of the test between the points marked *c* and *p* of Figs. 9 and 9a. The test illustrates, also, the contraction in the range of strain and width of hysteresis loop during a run at a very slow speed subsequent to a change from 200 per minute to that slow speed.

Table I.—*Portion of Test Specimen A* 10 *between Cycles* 1,442,600 *and* 1,483,400. *"Calculated" Stress* ± 6.50 *Tons per Square Inch.*

(See Figs. 9 and 9a.)

Cycles from beginning of Test.	Reference Letter on Figs. 9 and 9a.	Procedure.	Centimetres on Scale.
1,442,600	*c*	Running at 200 r.p.m. Range of strain	9.00
1,445,816	–	Machine stopped. Range of torque applied by weights. Range of strain (hysteresis loop not closed)	11.65
		Machine started at 2 r.p.m.	
1,442,826	*e*	Range of strain at 2 r.p.m.	10.69
		Running at 2 r.p.m.	
1,442,992	–	Range of strain at 2 r.p.m.	10.23
		Machine stopped. Rest of 35 minutes at zero torque.	
1,443,006	–	Ran a few cycles at 2 r.p.m. to obtain range of strain at 2 r.p.m. which was	10.20
		Machine stopped. Rest of 19 hours at zero torque.	
		Machine started at 2 r.p.m.	
1,443,018	–	Range of strain at 2 r.p.m.	9.90
		Running at 2 r.p.m.	
1,443,698	*f*	Range of strain at 2 r.p.m.	9.91
		Machine stopped.	
	g	Range of strain obtained with weights	10.28
		Rest of 6 days at zero torque, then 4 cycles, applied by weights:—	
1,443,698	*h*	1st cycle, range of strain, loop not closed	8.93
1,443,702	*k*	4th cycle, range of strain, loop nearly closed	9.38
		Machine started at 2 r.p.m.	
1,443,712	*l*	Range at 2 r.p.m.	9.10
		Running at 2 r.p.m.	
1,444,143	–	Range at 2 r.p.m.	9.73
		Running at 2 r.p.m.	
1,446,336	*m*	Range at 2 r.p.m.	9.73
1,446,340	–	Speed changed to 200 r.p.m.	
1,446,800	*n*	Range at 200 r.p.m.	8.40
		Running at 200 r.p.m.	
1,483,000	*o*	Range at 200 r.p.m.	9.02
1,483,255	–	Machine stopped. Rest of 4 days under zero torque.	
		Machine started, and speed run up to 200 r.p.m.	
1,483,000	*p*	Range of strain at 200 r.p.m.	8.40

Fig. 10 of specimen B 27 shows how the increase of range of strain, on change of speed from 200 to 2 per minute, varies with the extent of the range of strain. The width of loop at 2 per minute under the same conditions is also plotted.

Figs. 11 and 11a of specimen B 28 illustrate a test made to find how changes between various speeds intermediate between 2 and 200 per minute affect the range of strain. The number of cycles endured in the various stages of the test is plotted to the different scales marked on Fig. 11, in order to show more clearly the effects of rest and of change of speed.

All the specimens previously mentioned were hollow, turned and bored, and of small thickness of wall. Similar results were obtained with solid test-pieces. Fig. 12 of A 7 illustrates a test on similar lines to that of B 27. The calculated stresses—that, is stresses calculated from the torque on the assumption that the stress varies uniformly with the radius—are higher than for the hollow specimens. The range of stress at which non-elastic strain appears is a little more difficult to determine for the solid than the hollow test-piece. For A 7 this elastic limit appeared to be between ± 5.60 and ± 5.85 tons per square inch.

Tables II and III* are lists of the torsion tests done. All tests have been included (even those of hollow ones in which the bore was eccentric to the outer surface), except the first test done, namely, of A 3, which is of no use for any comparison, since the contemplated procedure was upset by the then unsuspected large effect of change of speed.

Alternating Bending Tests.—Figs. 13 and 14 illustrate the tests in alternating bending done upon specimens A 15 and A 16, a hollow and solid test-piece respectively. Bending and torsion tests gave results similar in every respect. The bending tests are given in Table IV.*

Mode of Fracture.—The fracture of the hollow specimens in alternating torsion were either always like that shown at A, Fig. 15, page 189, or if the crack was not far developed, like at B. It was clear that the straight part of the crack parallel to the axis was the first to appear, and that the pairs of cracks radiating from each end of this part were formed subsequently. The fractures of the solid torsion specimens were not all alike. That marked C, in Fig. 15, is exactly of the form of the hollow specimens, but on a smaller scale; that at D, in Fig. 16, has large serrations, and it is impossible to ascertain how the crack commenced. It was not as a rule possible to watch the development of the crack, because the strain-measuring apparatus obstructed the view; but as far as could be seen, it appeared that after the first hair-crack was visible, complete fracture or a very large crack would be developed in 10,000 to 40,000 cycles.

The cracks in both solid and hollow specimens under alternating bending commenced along a short circumferential line. The crack became deeper and the piece would or did break in a plane perpendicular to its axis, as shown in Fig. 16 at E.

(To be continued.)

* The width of the hysteresis loop affords a convenient measure of the cyclic plastic deformation. This loop is the curve obtained by plotting the strains against the corresponding stresses for a sufficient number of values of the latter throughout a cycle of stress. The width of this loop is thus, for alternating torsion, the difference between the readings of the angle of twist at successive half-periods of zero torque. The width is very nearly zero so long as elasticity is not impaired.

* As the results recorded in Tables II to IV are discussed in the concluding part of the paper, we defer the reproduction of the tables until next week's issue.

FOREIGN AND COLONIAL ENGINEERING PROJECTS.

We give below a few data on several Colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Australia.—The Imperial Trade Correspondent at Adelaide has forwarded a copy of the Loan Estimates of the South Australian Government, showing the estimated expenditure from loan for the financial year ending June 30, 1917. Among the items are the following:—1,701,332*l.* for harbour works; 550,600*l.* for waterworks, sewers, &c.; 251,400*l.* for water conservation, drainage, Murray River improvements, &c.; 146,339*l.* for irrigation and reclamation works; and 131,660*l.* for land settlement projects, &c.

Canada.—The Imperial Trade Correspondent at Toronto reports, under date January 9, that a shipbuilding company has been incorporated at Port Arthur (Ontario), with an authorised capital of 2,500,000 dols. (about 514,000*l.*), to acquire an existing dry dock and shipbuilding business, and generally to carry on the same. The address to which communications in this connection should be sent may be obtained by United Kingdom firms on application to the Department of Commercial Intelligence. In making application the reference number (80) should be quoted.

Republic of Colombia.—The *Diario Oficial*, Bogotá publishes a law (No. 53 of 1916) approving a contract entered into between the Colombian Government and Señor Evaristo Rivas Groot for the construction of a wharf on the Gulf of Morriosquillo, Department of Bolivar, the object of which is mainly to facilitate the export operations of a packing house company about to open up on the Atlantic coast. Construction work must be commenced within a year from the date of the passing of the law (November 24) and completed within a further two years. The law further grants general permission to the Government to enter into similar contracts for the construction of wharves destined to the services of packing houses commencing operations on the Atlantic or Pacific coasts of the Republic.

State Railway Extensions in Sweden.—Sweden may claim every credit for being alive to the claims of modern industrial evolution, and a statement made in the Diet on the reassembling of the Legislature showed that this also applied to the State Railways. Although technical improvements and extensions, it was said, ought to anticipate the increased demands made on transport facilities, exceptional circumstances, such as the present war, might arise when this was not possible. In order to meet present and future contingencies, an elaborate scheme had been prepared for the period of 1918 to 1927, for which latter year the gross receipts of the Swedish State Railways had been calculated to reach a total of 176,000,000 kronor against 150,000,000 kronor for 1916. The total cost of extensions of diverse kinds, including increase in rolling stock, &c., for the above period of 10 years, had been calculated at 504,500,000 kronor, of which 398,200,000 kronor were reckoned to be covered by grants, the balance, 106,300,000 kronor, being taken from the renewal fund. Although, on the occasion referred to, the Ministry thought the adequate efficiency of a concern of such vast importance as the State Railways must be maintained even if no full interest could be paid on the capital invested, still it was of material importance that the net profits, if possible, should represent a fair interest on the capital invested. Investigations undertaken pointed, however, to the fact that the situation aimed at could not be reached without a revision of the rates, owing especially to the high level of prices, which might be anticipated to continue to prevail during the decade under consideration. A readjustment of railway rates was therefore also under contemplation. The excessively high price for coal formed the principal feature in the additional outlay, and in consequence of this the question of reducing fuel costs received great attention. A scheme of extensive electrification of the Swedish State Railways was in course of preparation and was expected to be completed in the course of the present year. The use of peat powder as locomotive fuel were also being dealt with, and the State Railways were constructing a peat powder factory which was expected to be ready in the course of the forthcoming summer; its capacity was calculated at 20,000 tons annually. Should experiments on a large scale prove satisfactory, and should the price for coal remain high, the general adoption of peat powder for locomotive fuel would be given serious consideration.